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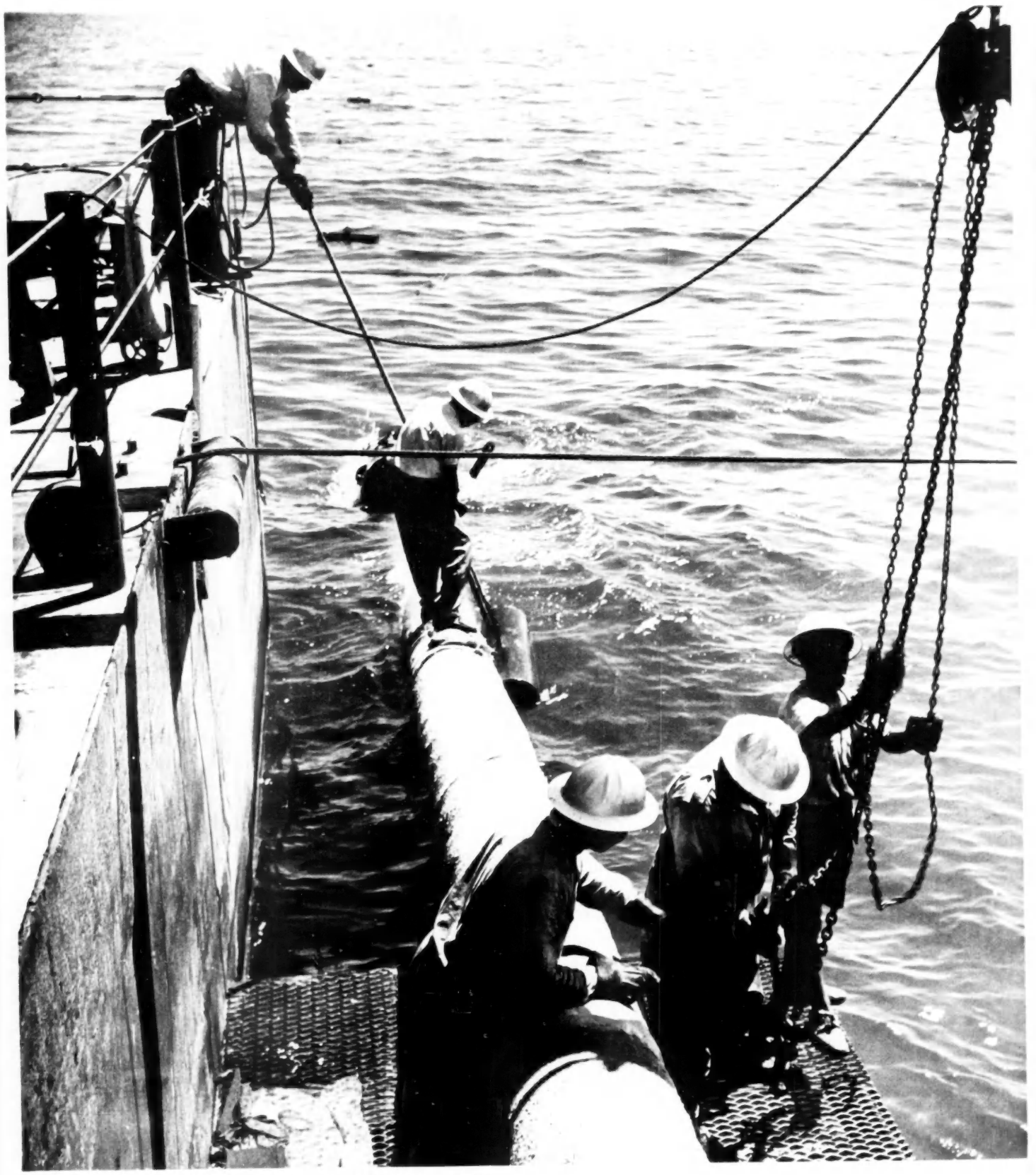

LAYING AN OIL PIPELINE IN THE CARIBBEAN

DECEMBER 6, 1957 VOL. 184 PAGES 705–736

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LOST HORIZON

On November 17, 1944, President Roosevelt sent a letter to Dr. Vannevar Bush asking him for his recommendations on the organisation of scientific manpower and scientific knowledge in the United States when the war was won. Thirteen years later, on November 25, 1957, Dr. Bush appeared along with Dr. Edward Teller to give evidence at the opening session of a Senate sub-committee investigating American lack of preparedness for push-button warfare.

Following President Roosevelt's letter in 1944, Dr. Bush made a series of recommendations which were based on the work of the various committees on technical development set up in Washington during the war to co-operate with the armed forces. His views were subsequently published in his book *Endless Horizons*. Approximately one-third of the book, which consists of collected papers, was a study of the training and mobilisation of scientific manpower in the electronic and atomic age. Last week Dr. Bush informed the Senate sub-committee that the American delay in missile development was due to "damaging and sometimes disgraceful" rivalry among the armed services.

The juxtaposition of these two events is suggestive. How was it possible for a Government towards the close of a war to see the need for continuing technological advance and the need to will the means of achieving it, and yet to be faced with a set of circumstances 13 years later which suggest, we know wrongly, that the problem had never been foreseen nor any action taken?

Informed American opinion places the blame for American inability to maintain its tremendous advantage at the end of the last war on an inferior basic educational system, lack of policy and action in channelling an adequate supply of young people into the sciences, rivalry among the armed forces and mistakes about the priorities to be given to different kinds of military technical development. Anyone who goes back to Dr. Bush's book will find all these problems displayed. It is appalling to think that such able crystal-gazing has gone for so little.

This situation has developed in the United States, which certainly indulged in an almost frantic demobilisation after the war, but one is left with the uneasy feeling that this country may have made the same mistakes. Signs are not lacking that in our somewhat smaller and less dramatic way we have also fallen short.

It is perhaps worth summarising very briefly some of the points in Dr. Bush's book which are painfully relevant to-day. To start with, President Roosevelt's directive to Dr. Bush (and to those committees of able men over which Dr. Bush presided) included a request for an effective programme to discover and develop scientific talent in American youth, so that "the continuing future of scientific research in this country may be assured on a level comparable to what has been done during the war." In the course of reporting on the President's directive Dr. Bush and his colleagues clearly foresaw what had to be done in broad terms, as the following quotations show.

"Improvement in the teaching of science is imperative, for students of latent scientific ability are particularly vulnerable to high-school teaching which fails to awaken interest or to provide adequate instruction." (Page 64.) "A part of the information now classified which should be released is possessed jointly by our allies and ourselves. Plans for release of such information should be co-ordinated with our allies to minimise danger of international friction which would result from sporadic uncontrolled release." (Page 68.) "There are certain kinds of research—such as research on the improvement of existing weapons—which can best be done within the military establishment. However, the job of long-range research involving application of the newest scientific discoveries to military needs should be the responsibility of those civilian scientists in the universities and in industry who are best trained to discharge it thoroughly and successfully." (Page 73.) "There should be a genuine scientific interlinkage between the two Services. . . . The failure of the two Services to have technical co-operation at all levels was . . . harmful to adequate preparation for the defence of the country." (Page 94.)

These remarks have a topical ring both in this country and in the United States. The conclusion is unavoidable that the Russian success in closing the technological gap owes much to Western blundering. This can be said without detracting in any way from the Russian achievement. The democracies foresaw the problems at a time when they were geared to solve them. Since the outbreak of peace we have dismantled the machinery. We have substituted vested interests and personal rivalries for the co-operation which went far towards winning the second World War, as described in two recent official British publications which are reviewed on page 720 of this issue. We have erected feeble pieces of administration with inadequate terms of reference. We have willed neither the materials nor the manpower to get results and even our priorities are suspect. The democratic approach prevailed in 1939-45. Is there any valid reason why it should not prevail now?

Cover Picture: *Where oil-drilling is off-shore—in sea or lake—pipelines are the easiest way of transporting the crude oil. The picture shows a submarine line being lowered into the water. Pontoons are attached to the pipes to control the buoyancy and prevent damage owing to undue stresses; the pontoons are released when the line settles on the lake or sea floor.*

* * *

Plain Words

Every professional man will sympathise with the doctor who was told last week that he should take a course to bring his knowledge of anaesthesia up to date. The advice came from a committee which had investigated the doctor's "professional competence."

In a profession as stern and unyielding as that of medicine, there is no room for a lack of competence which might go unnoticed in other professions. If it is your job to administer anaesthetics you have to know the correct practical methods and retain the necessary manual and mental skill whatever your age. Engineers, fortunately for themselves, order things differently. When they show signs of forgetting their mathematics, of lacking inventiveness in design, or of being slow to pick up the latest theories, that is the time to promote them to positions of supervision or management, where they can take a broader view and make use of the experience in guiding others. That, at least, has been a common solution in the past. But in recent years such a convenient let-out has become less readily available. In middle age, perhaps, the engineer is told that he must go on a course.

To soften the blow, course organisers are careful to call the course by another name. It may be "conference," or "seminar," or "study group" or some other name which suggests active participation rather than being lectured at. Even if the blow is not further softened by arranging social events—dinners, dances, receptions, conversaziones and the like—and even if the time-table is pretty gruelling, a course can be an agreeable relaxation. You meet people who are on the same professional level as yourself, but not necessarily in the same industry. You talk about anything and everything, like overgrown undergraduates. Just as physical training exercises muscles you had forgotten you possessed, so the course stimulates parts of your brain which you hardly knew existed. An industrialist whose name is familar to everyone through his business success and his television appearances attended a course himself recently, though he is, by the usual standards, well past course age. He gave the organisers and the other members of the course full value towards the end by weighing in with some hearty criticism of the course, the speakers and the organisers.

There is only one thing to beware of, when sent on a course. It is an honoured Army custom, if an officer must somehow be disposed of, to recommend him for the latest course which the C.O. hears about. When the poor fellow is ready to return, his post has been filled.

TRAINING FOR HARDSHIP

Naval Curriculum Contains the Pioneering Spirit

By Sub-Lieutenant M. K. Matthews, R.N.
Royal Naval Engineering College, Manadon.

In asking Sub-Lieutenant Matthews to provide us with a report of the Naval Colleges' Iceland Expedition we were aware that very few engineers outside the services expect to work under the sort of circumstances met with on such expeditions. But it is inevitable that the demand will arise for technically qualified men who can work under arduous conditions. Indeed the demand has already arisen in connection with the International Geophysical Year. And the readiness with which Russia is introducing industry into Siberia suggests that the industrial development of northern Canada or central Australia and, perhaps in the more distant future, Antartica, is not entirely out of the question.

In recent years the Royal Navy has developed a new type of training for its personnel, known as expedition training. Similar in principle to the Outward Bound system, it aims at providing opportunities for officers and young ratings to take part in small expeditions involving a degree of hardship. Such expeditions achieve many objects. Members learn a great deal about looking after themselves, and get ample experience for leading smaller expeditions, or for taking part in real exploration.

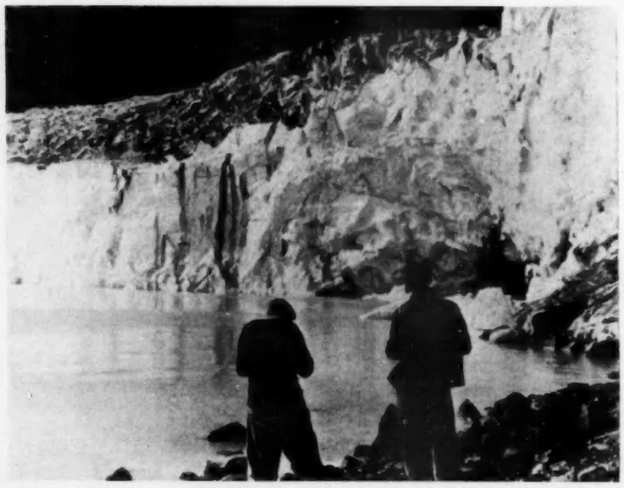
So far the emphasis has been on the training of young officers in order to fit them to organise and lead expeditions of this type when they go to sea. This year it was decided among the Royal Naval Colleges at Manadon, Greenwich, and Dartmouth, and the Royal Marine Infantry Training Centre at Lympstone, to approach the Admiralty for support in carrying out long distance expeditions to northern countries during the summer leave. Approval having been obtained, Iceland was chosen as a suitable place for the expedition, principally because of the better chances of transport. There would be plenty of scope for survey and other scientific work, and the existence of several ice-caps could be expected to provide valuable experience in ice work.

Captain J. A. Taplin, M.B.E., Royal Marines, from the Royal Naval College, Greenwich, was appointed leader of the expedition, and under him were selected four other leaders. Two medical officers were also chosen to accompany the expedition and, from many volunteers, 41 officers were selected from the four training establishments, in the ratio of numbers borne. Transport provided one of the main problems. The normal steamship service was heavily booked, and nearly all R.N. ships would be preparing for a large exercise. This problem was solved by the United States Navy, who agreed to fly the whole expedition from Exeter to the United States air base at Keflavik, in south-west Iceland.

All the heavy equipment and stores were sent by sea during July, and the advance party flew to Iceland on August 7 to set up the base camp before the arrival of the main party. The main party flew to Keflavik on August 9, spent the night at the air base, and next day travelled up to the base camp in two heavy-duty buses.

Iceland is a volcanic country, and the terrain consists mostly of vast lava fields covered with rocks and loose sand, with snow-capped peaks rising up from loose scree slopes. There are many fast flowing rivers and glacial streams with occasional waterfalls, and the sparse vegetation clings to the banks of these rivers. There are no trees. The centre of Iceland is virtually uninhabited, although sheep and wild ponies manage to survive wherever there is a little pasture land. The visibility is exceptionally clear, making distances deceptive, but after a dry spell the wind blows up great clouds of fine brown dust over the plains. In summer the country is free from ice and snow except for the tops of the mountains, and the four main ice-caps, which cover many hundreds of square miles.

The base camp for the expedition was situated by the river Svarta, six miles to the east of the Langjokull ice-cap, and was reached after a journey lasting about seven hours over roads which were little better than wheel tracks across the lava.



The centre of Iceland is virtually uninhabited. Much of the terrain consists of lava fields covered with rocks and loose sand. Two members of the Iceland expedition are shown facing the icefall at the foot of Nordurjokull, on the shores of Lake Hvitarvatn.

During the first few days small parties went out to reconnoitre the surrounding countryside and to gather enough information to form a basis for the work of the expedition. A large area of marshland was discovered between the base camp and the foot of the ice-cap, along the shores of Lake Hvitarvatn. Wild ponies, sheep, and many species of duck inhabit this marsh, which became the centre of the ornithological investigations. Another party found a route up to the ice-cap, where it was intended to establish a meteorological post. The survey parties climbed all the surrounding peaks, searching for trigonometric points, and deciding on the extent of the area to be surveyed. Within a week the meteorological post on the ice was

operating, and the work of all three departments was in full swing.

The expedition was divided into five equal groups, which were called "fires," and each "fire" formed a separate group for purposes of drawing stores and eating, and for the work undertaken. Two fires were responsible for survey and meteorology, one fire for ornithology, and two fires for general duties.

The food consisted of oatmeal, processed cheese, biscuits, margarine, dehydrated vegetables, rice, pemmican, "high fat bars," chocolate and glucose tablets. Breakfast took the form of porridge, biscuits, and cheese; lunch was biscuits and cheese; and the evening meal consisted of a highly sustaining stew called "hoosh," which was made by soaking and boiling the vegetables and rice, and then adding the pemmican and high fat bar. A day's rations contained over 5,000 calories, which is considerably more than a person consumes under normal circumstances. Half a ton of biscuits, a quarter of a ton of processed cheese, and over 3,000 bars of chocolate were eaten during the forty days of the expedition.

Clothing was very much an individual affair, depending on the weather and the altitude. When on the ice-cap, string vests, two or three sweaters, wind-proof anarak clothing, mittens and snow goggles were generally worn. Heavily studded boots were the only type of footwear which stood up at all well to the extremely rough country. When on the march, each person had to carry spare clothes, sleeping bag, groundsheet, and—with a share of the tents, cooking utensils, primus stoves, paraffin and food—this amounted to about 60 lb. for a four-day journey. When crossing rivers, the best technique was to wear gym shoes in order to keep boots dry, and for the leader to sound the depth with an ice axe. Occasionally the depth would be waist high, and the water was always fast flowing and very cold. Parties which crossed the ice-cap wore skis and often used a sledge to carry some of the provisions. The surface of the ice was mainly covered with frozen snow, but rain sometimes turned this into slush.

The surveying was under the charge of Captain J. S. Coulson of the Royal Engineers, and working with him were sixteen other officers, none of whom had much previous experience. Existing maps of the area were all based on aerial survey, and many of the details, particularly contour heights, were inaccurate. The first fortnight was spent in making a trigonometric survey of the area to be mapped, this was then split into different sections and the details filled in by surveyors working in pairs with a plane table. A map was finally produced of an area of 60 to 70 square miles, with a scale of 1 : 50,000, and 5 metre contour intervals.

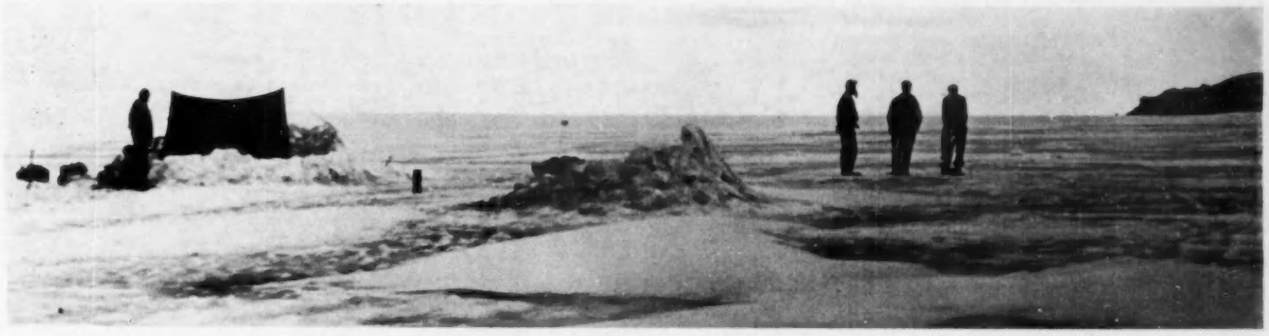
The ornithologists spent much of the time away from the base camp, seeking the haunts of the many different birds which were to be seen near the marsh. Mr. J. S. Barlee, a lecturer at Dartmouth, was in charge of the ornithological studies, and he also directed the 16 mm. colour film which was taken of the expedition's activities. Much of the work of this party consisted of photographing and listing the different species of birds.

There was no trained meteorologist on the expedition, but this was not much of a handicap, as the work consisted entirely of taking observations, and many of the officers had some previous experience. Two meteorological posts were set up, one at the base camp at an altitude of 1,400 ft., and one on the ice-cap at 3,300 ft. Living for four days at a time on the ice was sometimes a little uncomfortable, particularly in high winds and when it rained or snowed. Readings were taken every three hours of pressure, temperature, wind speed and direction, visibility, cloud formation and rainfall. Daily weather reports were sent from the base camp to Reykjavik by wireless. The average daily temperature at the base camp during the expedition was 48 deg. F., on the ice-cap 34 deg. F., and the lowest temperature recorded on the ice-cap was 24 deg. F. It was generally cloudy and windy, and rained on over half of the days.

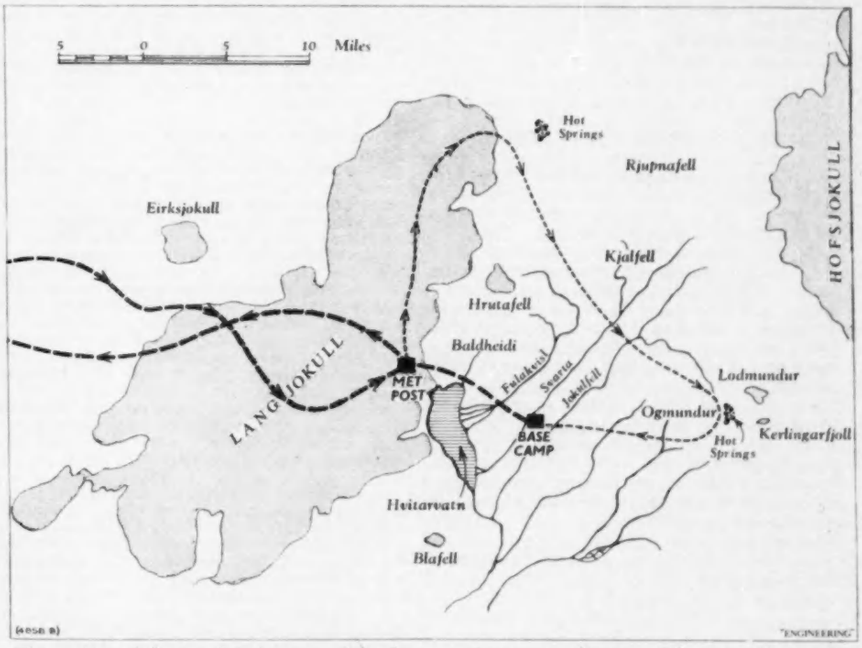
There were many opportunities for officers to go away in small groups for a few days to visit hot springs, cross the Langjokull, or go ski-ing in the mountains. Although by no means a beautiful country, Iceland has many fascinating features, among them being numerous snow-capped mountains, hot springs, waterfalls, northern lights, rainbows and magnificent sunsets.

The expedition ended on September 11, and the last two days were spent packing gear, some of which was to be stored in Iceland for next year's expedition. The journey back was similar to the outward one, and the expedition arrived at Exeter on September 12. At the start, it was decided that members of the expedition should contribute two-thirds of their pay and allowances while in Iceland towards the cost of the expedition, and that they should provide themselves with certain items of personal equipment. The Nuffield Trust contributed £1,000, and the Royal Geographical Society £50. Most of the equipment, stores, and food were obtained from Service sources, or from the equipment already in use by Manadon and Dartmouth.

The expedition was an undoubted success. It gave its members valuable experience under reasonably hard conditions. Everyone enjoyed himself and came back very fit and well.



One of the activities of the Royal Naval Colleges' Iceland expedition was the setting up of a meteorological post on the Langjokull ice-cap.



The position of the expedition's meteorological post can be seen on this map of the area. Two typical routes taken by members across the ice-cap are shown.

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The Index to Volume 183 of ENGINEERING (January-June, 1957) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher, 35 and 36 Bedford-street, Strand, London, W.C.2. Any reader wishing to receive regular copies of the Index as they are published can apply to be put on the mailing list. Those already on the mailing list need not re-apply.

Letters to the Editor

LIGHTING OUR ROADS

SIR, Mr. W. Robinson's excellent articles on industrial lighting outline the requirements for comfortable, safe, and glare-free working conditions. ("Management, Lighting and Engineers," ENGINEERING, November 8, page 578; November 15, page 626; and November 22, page 658.)

Our public authorities seem to be singularly lacking in awareness of the need for similar conditions in road lighting. It is an elementary rule for safe lighting, that the source of light should not be visible directly to the eye, but how few of our road lighting systems comply with this requirement. Many main roads are inadequately illuminated with a brilliant line of dazzling points, quite unshielded sideways or upwards, each having a black patch on the road underneath, on which a dark coloured object is invisible a few yards distant.

ENGINEERING could make a valuable contribution to road safety, by giving photographs of good and bad systems and, while on the subject of road safety, may we hope that the new roads now being built will be free from sewers, pipelines, electric cables, etc., and their attendant hazards of access manholes. Surely roads are for transport, not tracks for services which should be in open country?

Yours faithfully,

J. R. HOWARD.

33 Stoney-lane,
Quinton,
Birmingham 32.
November 28, 1957.

THE NATURE OF DESIGN

SIR, From the paragraph entitled "Design in Engineering" on page 650 of ENGINEERING for November 22, it seems that some clarification of the word "design" is needed. There are wide differences between "industrial design," or "styling," and the way the engineer uses the word "design." To the engineer, the "design" is the thing itself, in all its details, as defined in the product drawings and process instructions issued for manufacture. Research and development are the raw materials: in the design stage they are processed into a usable form.

The statement that "Quality in engineering goods is not the same as design, but often it is closely related to it"—is startling. Quality, in every sense of the word, including general character, endurance, performance, accessibility, convenience in use, and so on, is surely almost entirely a matter of design.

Yours, etc.,

HUGH CLAUSEN.

17 Harman-drive,
London, N.W.2.
November 23, 1957.

PLASTICS FOR HIGH TEMPERATURES

SIR, We wish to refer to the article on page 654 of your issue of November 22 entitled "Developing Plastics for Higher Temperatures."

It appears that some of the information provided by the present writer at the Press conference on October 29 has, in some measure, been misinterpreted. There are no serious inaccuracies, but you may possibly receive some correspondence on one or two technical points.

At the foot of the second column the article reads "Previous large molecules for plasticisers have been terminated by ester groups." This should read "have been terminated by polar or hydroxyl groups." The value of *n* in the opening paragraph of the third column cannot be definitely stated as 20. I think that the number 20 was given during the questions at the end of the address but this value is the maximum possible and should not be regarded as normal. The last paragraph indicates that diolpates are mainly used for the cable coverings. In point of fact, they are being extensively used in the plastics industry generally, and it is incorrect to say that diolpates are only used for cable coverings.

We hope the above remarks will be helpful and we thank you for the comprehensive nature of your report. We feel that this is one of the best reports which we have seen.

Yours faithfully,

L. W. TOWNSEND,
Managing Director.

Permanoid Limited,
New Islington,
Manchester, 4.
November 27, 1957.

MORE STEEL OR BETTER CONCRETE

SIR, The article by Dr. J. R. Lawrence on "More Steel or Better Concrete for Cheaper Designs," in your issue of November 1, page 564, is an interesting example of a correct mathematical analysis leading to incongruous results because of incorrect assumptions on which the analysis is based.

The author has taken great pains to investigate his problem very thoroughly by taking into account three different values of the modular ratio and has arrived at the conclusion that, within the wide range covered by his calculations, "the optimum value of the maximum steel stress, giving a minimum total cost for rectangular beams" is "between 8,000 and 25,500 lb. per sq. in." He goes on by saying that "under no circumstances can the use of a more expensive steel, albeit with a higher maximum permissible stress, give any advantage in the total cost over the use of mild steel reinforcement with a maximum permissible stress of 18,000 lb. per sq. in." This rather sweeping statement, which is contradicted by the curves showing a minimum cost at stresses up to 25,500 lb. per sq. in., must have surprised many practising engineers who have used high tensile steel in their designs for many years in the belief that by doing so they were reducing the cost of their structures. Admittedly, the author qualifies his conclusions in the last paragraph by emphasising that they apply only "to simple rectangular beams" but this qualification is not enough as will be seen from the following.

In fairness to the author the problem has to be discussed first on the basis of the 1948 Code and only afterwards on the basis of the 1957 Code which was apparently unknown to him when he wrote his article.

It is common knowledge to reinforced concrete engineers that the so-called "economic" percentage at which both the concrete and the steel are stressed to their maximum permissible value, is not necessarily the most economical percentage for rectangular beams if the design is based on the standard method. However, from the practical point of view, this is of little significance since rectangular beams, in contrast to slabs, which will be dealt with separately, are rather exceptional in reinforced concrete structures.

Apart from parapet beams, or beams passing through openings, the great majority of beams are T- or L-shaped in which the concrete is very rarely stressed to its permissible limit in the span. At the supports of continuous beams, where the relevant section is rectangular, it is generally necessary to provide compression steel, either by adopting the well-known "steel-beam" theory (ignoring the concrete stresses altogether) or by reducing the stress in the tensile reinforcement in line with the author's suggestions for rectangular sections without compression reinforcement.

If the author applied his method to T-beams he would find that, in practical cases, the minimum cost is obtained with the maximum permissible tensile stress in the steel. A continuous T-beam "over-reinforced" in the span requires so much steel at the supports that it is hardly practicable, except with haunches which are not very popular with architects and contractors.

Let us now consider slabs the cost of which is, of course, a substantial part of the total. Strictly speaking, the author's analysis does not apply to slabs (though they are also of rectangular cross-section) because he has assumed a constant depth (d) and achieved the reduction of the volume of concrete by reducing the breadth of the section (b). In slabs b is constant and the volume of concrete can only be reduced by reducing the depth. An analysis based on b being constant instead of d would undoubtedly result in different curves, but the principle (i.e., the reduction of the volume of concrete as against an increase of the weight of steel) would still be the same, with a minimum cost at slightly higher steel stresses than in the author's diagrams.

It has to be borne in mind that limitation of stresses is not the only consideration in design; serviceability is of equal importance. One of the essential requirements is the limitation of the deflections. It is for this reason that the new Code of 1957 limits the span/depth ratio for slabs spanning in one direction, simply supported, to 30.

This limitation was not included in the Code of 1948, but the Code of Practice C.P. 114, 100 (issued in 1950) limited the effective depth of slabs to the span divided by 35. The following numerical example may demonstrate the significance of the span/depth ratio.

Span, 15 ft. Superimposed load (including finishes and partitions) 100 lb. per sq. ft. Minimum permissible thickness, $\frac{180}{30} = 6$ in. Deadweight 75 lb. per sq. ft.

$$\text{Maximum } M = \frac{15^2 \times 175}{8} = 4{,}920 \text{ lb.-ft.}$$

With ½ in. cover and bars of ½ in. diameter the effective depth is 5·25 in. Hence $R = \frac{M}{b d^2} = \frac{4920}{5 \cdot 25^2} = 178 \cdot 5$ lb. per sq. in.

This, with F = 18,000 lb. per sq. in., corresponds to a concrete stress of only 950 lb. per sq. in. Combining the author's lowest steel stress, 8,000 lb. per sq. in., with f = 1,000 lb. per sq. in., R = 256 lb. per sq. in. With this value, the thickness of the slab could be reduced by 1 in. The bending moment would then be

$$4920 \frac{163}{175} = 4{,}580 \text{ lb.-ft. and } R = \frac{4580}{4 \cdot 25^2} = 253 \text{ lb. per sq. in.}$$

However, the over-riding condition is the span/depth ratio which would be 36 and thus prohibitive. The ratio span/effective depth $= \frac{180}{4 \cdot 25} = 42 \cdot 3$ would have been prohibitive on the basis of the 1950 Code for slabs.

By assuming a continuous slab, which occurs much more frequently than simply supported slabs, the discrepancy between the depth obtained on the basis of the author's suggestion and the limit governed by the span/depth ratio (35 according to the Code of 1957) would be even greater. The gap would be further increased by the use of high-grade concrete. It could be argued that the calculated deflection of a 5 in. slab with 4·08 per cent. reinforcement stressed to only 8,000 lb. per sq. in. is less than that of a 6 in. slab with only 1·16 per cent. reinforcement stressed to 18,000 lb. per sq. in., but it might be rather difficult to get this accepted by district surveyors or local authorities who are bound by existing Codes. In the case of rectangular beams, it is not only the span/depth ratio but also the span/breadth ratio which restricts the reduction of the volume of concrete. According to the 1948 Code the working stress on the concrete had to be reduced if the lateral slenderness ratio exceeded 20.

There is a further obstacle to the practical realisation of the author's results. In the above example the sectional area of the reinforcement of the 6 in. slab designed for F = 18,000 lb. per sq. in. is

$$0 \cdot 0116 \times 5 \cdot 25 \times 12 = 0 \cdot 73 \text{ sq. in. per ft.}$$

This can be provided by ½ in. bars at 3 in. centres, or preferably, by ⅝ in. bars at larger spacings, which is cheaper. In this case the effective depth is reduced to 5·07 in.

$$R = \frac{4920}{5 \cdot 07^2} = 192 \text{ lb. per sq. in.}$$

f = 1,000 lb. per sq. in., $A_S = 0 \cdot 01263 \times 5 \cdot 07 \times 12 = 0 \cdot 77$ sq. in. per sq. ft. or ⅝ in. bars at 4½ in. If F is reduced to 8,000 lb. per sq. in. and the effective depth to 4·25 in. the required sectional area of the reinforcement is $0 \cdot 0408 \times 4 \cdot 25 \times 12 = 2 \cdot 08$ sq. in. per ft. It is impossible to provide this quantity of steel in the form of ½ in. or even ⅝ in. bars; the choice is between ¾ in. bars at 3½ in. centres—which is bad—and 1 in. bars at 4½ in. centres. With 1 in. bars, a cover of 1 in. is necessary so that the minimum slab thickness is $4 \cdot 25 + 0 \cdot 5 + 1 \cdot 0 = 5 \cdot 75$ in. However, owing to the increased deadweight, the assumed effective depth of 4·25 in. is no longer sufficient, since

$$R = \frac{172}{175} \times \frac{4920}{4 \cdot 25^2} = 267 > 256,$$

so we are back again at 6 in. thickness as before with almost three times the reinforcement.

The preceding example, taken at random, is in no way artificial, except for the assumption of the lowest value of F suggested by the author. It is characteristic of conditions in offices, blocks of flats, schools, etc.

We see, therefore, that the author's conclusions can only apply to cases in which the superimposed load is comparatively heavy. Even this limited range of validity shrinks to nothing if we design on the basis of the new Code of 1957.

The Code of 1948 relied entirely on what the author calls "the classical theory" for the design

WITH the first issue of ENGINEERING for 1958, several improvements in design will be introduced.

To make the journal easier to handle, the overall page size will be reduced from 14¼ in. by 10½ in. to 13¾ in. by 10⅛ in. We are able to do this without affecting the area or amount of editorial matter because our present margins are unusually wide. Square-back binding will replace the present saddle stitching, thereby further contributing to easier handling and at the same time allowing all classified advertisements to be grouped together at the front of the journal, even when there is an exceptional number of pages to be accommodated.

These changes presented us with an opportunity to improve the design of the front and back covers in the light of recommendations which have been made in recent years by the British Standards Institution, Aslib and other organisations whose members represent the users of technical journals. The new arrangement is shown in the photograph of the front cover. It conforms with all the important recommendations of these organisations; it has the cardinal virtue of all good design—simplicity; and it maintains a reasonable continuity with the present front cover in the use of a special photograph combined with a green band at the top. The back cover has been similarly modernised, without altering the advertisement area.

At the top left-hand corner a new house symbol is introduced. It will quickly become familiar to readers of ENGINEERING, and serve as a recognition signal not only on the cover but also on all our correspondence and stationery generally. The titles of some of the principal articles appear on the left-hand edge, and there is ample room for the circulation slip which is usually fixed to journals that have to be seen by all departments.

These changes will be outward and visible. Inside the journal, in the editorial pages, we shall continue to keep abreast of contemporary thought and practice in man's economic application of scientific discovery.

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as set out in his equations 1 and 2. It has been known for a long time that this classical theory is based on incorrect assumptions and is contradicted by tests. Suffice to say here that the stress-strain diagram of concrete is not a straight line and that creep causes a redistribution of stresses which plays havoc with the assumptions of the classical theory. The "modular ratio" varies with increasing loading and also under sustained loading in the course of time. Its variation in design is pure self deception since its introduction into the design is entirely superfluous. The "classical method" would have been abandoned long ago but for wrong technical education, the vested interest in existing text-books and the mental inertia of many engineers. At last, the Code of 1957, following the example of other countries with a broader outlook on technical matters, has introduced as an alternative the "load factor" method, which is much more in line with the physical properties of the materials.

According to the Code of 1957, the resistance moment M_r of a rectangular beam or slab section without compression reinforcement (corresponding to the working loads) is the lesser of the two values:

$$A_{st}\, p_{st}\, l_a \quad \text{and} \quad \frac{p_{cb}}{4}\, b\, d_1^2$$

where

l_a is the lever arm which may be taken as $d_1 - \frac{3\, A_{st}\, p_{st}}{4\, b\, p_{cb}}$.

A_{st} = cross-sectional area of tensile reinforcement,

p_{st} = permissible tensile stress in the reinforcement,

p_{cb} = permissible compressive stress in the concrete in bending,

b = breadth of the section, and

d_1 = effective depth to the tensile reinforcement.

For p_{cb} = 1,000 lb. per sq. in. the limiting value of M_r is 250 $b\, d_1^2$. This is only about 2 per cent. less than the value obtainable with the same quality of concrete on the basis of the Code of 1948 if F = 8,000 lb. per sq. in., and can be achieved with p_{st} = 30,000 lb. per sq. in. if high tensile steel of a minimum yield point or proof stress of 60,000 lb. per sq. in. is used. As long as

$$A_{st}\, p_{st}\, l_a \leq \frac{p_{cb}}{4}\, b\, d_1^2$$

the calculated concrete stress is irrelevant from the point of view of safety.

The anomaly of the Code of 1948, whereby the cost of certain structural members subjected to bending only can be reduced by reducing the working stress in the tensile reinforcement, very clearly demonstrated by the diagrams of Dr. Lawrence, has been eliminated by the Code of 1957. A saving in cost can always be achieved by the use of high tensile steel provided that the percentage increase of the cost per unit weight of steel is less than the percentage increase of the permissible tensile stress.

Yours faithfully,
K. HAJNAL-KÓNYI.

7 The Park,
Golders Hill,
London, N.W.11.
November 23, 1957.

WORK STUDY CRITICISMS

SIR, In a review of *Outline of Work Study—Part III: Work Measurement*, on page 562 of your issue of November 1, you say: "Critical comments on time study practices which have been made in the past by experienced men, who are also distinguished academically, are not brought to the attention of the reader. This is to be regretted. . . ."

It is indeed; I should like to join your reviewer in deploring this tendency to ignore such comment. And not only should we listen to outside sources: the strongest criticisms of work study should come from us who practise it. Presumably, we know more about the practical applications of our own techniques than any external critic, and our training in analysis and reconstruction might well be applied to these techniques. "Why beholdest thou the mote that is in thy brother's eye, but considerest not the beam that is in thine own eye?"

Your reviewer is on less certain ground when he writes: "Work study technicians have been responsible for increasing production by amounts up to 200 per cent. over pre-study values, though such marked increases necessarily indicate initial bad management."

Spare a tear for the poor harassed manager. He may have inherited a process which has not changed since grandfather's day. In a hastily-snatched moment between placating his employees, his directors and the local trade union he asks the work study department to examine the job for him. What a paragon among managers! He has the courage to admit that something needs correcting, the co-operative approach to an advisory department, and the shrewdness to select a job which is running at a lower efficiency than any other.

Would your reviewer still claim that this imaginary (but not improbable) manager is *necessarily* inefficient?

Yours faithfully,
A. BATTERSBY,
Work Study Manager.

A. Boake, Roberts and Company Limited,
Carpenters-road, London, E.15.
November 25, 1957.

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BURMA AND PYIDAWTHA

Burma is associated in most minds with teak, rice and the road to Mandalay. It could also be a good market for British engineering products. Like most countries in South East Asia, Burma has taken to the idea of economic planning. The object of the Burmese development plan—Pyidawtha—is that by 1959/60 the inhabitants of Burma should be producing nearly one-third more than they were before the war. When the plan was first mooted in 1952, it was estimated that £562 million of capital investment would be needed between January, 1952, and September, 1960. Plans hitherto have been mainly concerned with developing natural resources, especially agriculture. A new volume in the series of Overseas Economic Surveys, *Burma* (H.M. Stationery Office, 4*s*.), published last week, points out that industrial development is also being carefully considered. Industrialisation cannot however be achieved without adequate power, transport and communications. Burma's communications and electrical plant have to date been constructed under British guidance and with equipment made to British standards. United Kingdom manufacturers should therefore start with a big advantage in bidding for the supply of goods under all sections of the communications programme.

In the circumstances, recent trends in trade, which show a marked fall in British engineering exports to Burma, seem surprising. In 1956, United Kingdom exports of metal manufactures to Burma totalled £2·0 million, compared to £3·6 million in 1955. Machinery exports fell by 17 per cent. to £3·0 million, while exports of electrical machinery fell by 33 per cent. to £1·2 million in the same period. United Kingdom exports of road vehicles and aircraft showed an even bigger drop of 68 per cent. to £783,000. The reasons for this decline are not hard to find. In the first place the Burmese development plan was based on the assumption that the export price of rice would not fall much below £55 per ton in the first few years of the plan. In fact the price fell heavily in 1953 and now stands at little over £30 per ton. Hence many projects have been held back due to shortage of foreign exchange. Secondly, it has been found necessary to conserve foreign exchange by imposing a number of embargoes on imports, although so far as possible these have been enforced so as not to exclude imports which are vitally needed for the development plan. Thirdly, United Kingdom exports must face competition from goods that can be supplied from Japan under the reparations agreement at no cost to Burma, and from imports from "barter countries" supplied in exchange for Burmese rice.

The outlook for British exporters under these circumstances does not appear propitious. However, some of the problems (certainly reparations, and perhaps cheap rice) will eventually disappear. The Survey suggests that if British manufacturers continue to show a patient interest in the Burmese market, it will be profitable for them in the long run. The dawn will come up—if not like thunder.

Companies in the News

New Engines for Old

The British aero-engine industry shines like a light in the enveloping gloom, as an example of bold thinking and a determined concentration on quality. While none would deny praise to the designers of the successful British post-war aircraft, a large part of their success has been due to the availability of engines which at the time of their introduction were revolutionary. Whatever gloomy forecasts may be made of the aircraft industry's future, there can be little doubt concerning the expanding exports of aero-engines as such. The total value of engine exports for the first ten months of 1957 was nearly £32½ million, almost £10 million more than in the corresponding period last year. The rate of exports has almost doubled since 1955.

The finances of the world's airlines, in spite of their striking growth, remain on a foundation, if not of sand, at least of pretty soft rock, and the raising of the huge sums needed for new fleets of modern aircraft remain a constant pre-occupation. The scheme put forward by D. Napier and Son, Limited, for re-engining existing piston-engined aircraft with Eland turboprops should therefore meet with some considerable success.

Though this project has been under way for some considerable time, a further stage was reached recently. Napier's demonstration Convair 340 fitted with two Elands has now crossed the Atlantic for demonstrations in Canada and afterwards for airworthiness certification trials by the United States Civil Aeronautics Administration. The airliner already holds a Special Category Certificate issued by the Air Registration Board. Weighing no more than the piston engines they replace, the Elands between them give more than 2,000 extra horse-power.

Some 400 Convairs are in use or on order by 27 airlines and many are showing a considerable interest in Elands; one South American airline has already placed orders. Furthermore, none of the airlines with Convairs in use or on order are British, so that all orders represent further exports.

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From the Heart

Giving evidence before the Select Committee of the Commons on nationalised industries (Reports and Accounts), Sir James Bowman, chairman of the National Coal Board, said " If you were just to say to the Coal Board—and how I would welcome it— ' From now on, you are free to act as a commercial concern,' then I think we might be able to show rather different results."

Recent criticism of the Board on the ground that output of large household coal is inadequate led to comment by several observers that something should be done about prices. The Ministry of Fuel and Power have preferred to keep on domestic rationing to prevent demand from rising some 1½ million to 2 million tons a year. In all probability this could be large coal, which has been imported this year while stocks of small coal continue to pile up. Now the Ministry have announced that no more will be imported next year. The consumer's preference for large coal will presumably be held in check by rationing.

The Board have said little so far on this question, except that they will put emphasis upon the uses of certain power-loading machines that do not degrade coal size too badly and that they are asking the pits to increase their output of large coal in any way that they can. But Sir James's remark quoted above is the key to the whole situation. The coal seams in this country are not suitable for effective mechanisation of the mining of large coal. The machines were put in to maximise coal getting. Sir James said that the Board are not " flesh, fish or good red herring." They are neither a public service nor a commercial undertaking. But, without imports, they are a monopoly. Can they, or will they, produce the coal of the quality we need at a price we can afford while at the same time earn the profits required to keep themselves up to date and effective? In the present circumstances this is most unlikely.

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B.S.A. Reconstructed

Great emphasis was laid upon a well-balanced board by Mr. John Y. Sangster in his annual speech to the shareholders of the Birmingham Small Arms Company. " I am convinced," he said, " that a Board, well balanced as between executive and non-executive directors, is best suited to manage the affairs of a large group of companies." The appointment to the board of three men " of exceptionally wide experience and of the highest possible standing in the business world "—Mr. G. G. Phillips, Mr. A. J. Quig and Sir James Reid Young—will bring to the group critical faculties from other fields of industry and commerce which the executive directors should find extremely valuable. Increasingly companies are finding it desirable to draw upon such " outside " directors to avoid falling into a rut. The growing complexity of modern business, and its wide inter-relation, is creating a need which is felt even by much smaller companies.

For the first time B.S.A. publish the division of their turnover as between the various sections in the group. The analysis presented excludes the turnover from pedal cycles, as the group's interests in that industry have been sold to Raleigh. The largest turnover, 27 per cent. of the total, was in motor-cycles and auto-cycles. The three companies concerned, B.S.A., Triumph and Ariel, account for more than 60 per cent. of the total output of the British motor-cycle industry. As in the case of cars, sales slumped in the early part of the financial year (ended at July 31) but " a remarkable recovery took place in the summer months " and has been well maintained. A new scooter has been developed and will be in production this year. Machine tools and small tools account for 23 per cent. of the group turnover and probably a much higher proportion of group profits. The feature of the year was the installation of a new section for the production of automatic transfer machines. Steel and titanium (18 per cent.) had " a most successful year " and Mr. Sangster reports that technological advances, in special steels and in high-strength materials, are " at an ever-increasing tempo."

Motor-cars and buses (Daimler) made a loss but contributed 14 per cent. of total turnover. Small arms and general engineering (18 per cent. of turnover) complete a pattern which incorporates a good balance between capital and consumer goods.

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Green Light for North British

Last week, the first powerful Diesel-hydraulic locomotive to be delivered to British Railways was completed at the Queens Park, Glasgow, works of the North British Locomotive Company Limited. Weighing 116 tons and with a rated capacity of 2,000 h.p., the locomotive, No. D600, will be put into service on the Western Region after running-in trials in the Glasgow area. Only a few days before, North British had received an order for 52 main-line Diesel-hydraulic locomotives of 1,000 h.p. each, which brings their total order book under the railway modernisation plan to 63 locomotives, of which 5 will be of 2,000 h.p. This is the largest single order placed to date by British Railways for Diesel locomotives, and is a substantial part of the total of 130 locomotives of this type which will replace 200 steam engines to give a complete Diesel service west of Newton Abbot and provide the power for many through expresses from Paddington to the west of England.

Commenting on the latest contract, North British say that, together with other orders on hand, their order book is now in excess of £5 million. This will provide full employment for some years to come and may well entail an expansion of the present labour force—ample justification for the re-equipment of the Queens Park works to produce M.A.N. Diesel engines and Voith transmissions under licence from Germany.

As North British pointed out last week, interest in Diesel services is not confined to this country. Many of the company's traditional markets abroad are changing from steam to Diesel traction and success at home will prove the worth of British Diesel locomotives to overseas buyers. British locomotive manufacturers have not had conspicuous success abroad in recent years, and this has not been entirely due to the declining interest in steam. United Kingdom exports of steam locomotives dropped from £11·0 million in 1954 to £4·1 million in 1956, but there was no compensating increase in exports of Diesel locomotives. The conclusion is inescapable that our competitors have built up a lead in this important field. This lead may now be in process of reduction as the British locomotive industry continues its switch from steam to Diesels. In addition to North British, Robert Stephenson & Hawthorn Limited are not building steam locomotives, though they have large orders in hand for Diesel-electric locomotives for Malaya, India and Argentina.

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Blind Landing

Few complacent people can be found in the aircraft industry after the series of shocks administered to it in the past six months. Mr. E. C. Bowyer, director of the Society of British Aircraft Constructors, said that firms were " seriously worried " about the extent of the cuts in the research and development programme likely to follow the reduction in the Government's outlay. The Society fears cuts averaging about one-third of the present level. This, Mr. Bowyer said, could cripple the industry's exports, which amounted to £104 million last year and were at a slightly higher level so far this year. It was the second largest engineering export industry, he said, and implied that it was worth supporting in its efforts to gain and maintain technical leadership.

Clearly a crisis is building up fast. Whether or not the Government should keep pumping money into the industry is not at all clearly established. Lord Week's suggestions for a much closer integration of manufacturing facilities (and therefore a more economical concentration of research and development) was not mentioned by Mr. Bowyer. The chairman of the Fairey Aviation Company, Mr. Geoffrey W. Hall, had this to say at the 29th Annual General Meeting of his company: " Enforced rationalisation could readily squander the long background of experience and the competent teams which have been built up over the years. Satisfactory solutions will have to be found to encourage and maintain the pioneering spirit, and willing collaboration between firms can be an answer, provided that there is sufficient work available. Large mergers or a State-controlled industry are not the only roads to success." Mr. Hall's point, that moderately sized companies are well fitted to play this part, " operating in collaboration with the other specialised concerns " is proven by the performance of some companies, such as his own and the much smaller Folland Aircraft, but not an answer for the whole industry. Folland's chairman, Mr.

C. L. Hill, refrained from comment on this vital issue. Yet his company are the shining example of a successful private venture work by a relatively small company with a turnover of just over £2 million and employment of 2,110. An order book of £6 million is a tribute to their enterprise and judgment. But the fact remains that Folland as well as other larger firms in the industry are primarily arms manufacturers.

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Engines Unlimited

Recent statements by manufacturers of Diesel or petrol engines indicate that demand continues brisk for this form of power. The acquisition by the Villiers Engineering Company during the summer of J. A. Prestwich Industries Limited has created one of the largest organisations manufacturing small petrol engines. With the tremendous growth of demand since the war—in power cultivators, garden tools, scooters, mo-peds, small cars and others—a host of appliances and conveyances now require engines up to 800 c.c. This is a field where the Diesel is yet unable to operate and one in which the manufacturers of motor cars will have no particular interest until and unless the small family car, such as the Frisky or the German Goggomobil, find a market much larger than is anticipated by the big firms.

Mr. Leslie W. Farrer, Villiers' chairman, announced slightly higher trading profits at £494,000 which he considered a most satisfactory performance in view of the "exceptional difficulties" that had to be overcome during the year ended at July 31. He looked forward to "considerable economies" from the merger with J.A.P. and thought future prospects favourable. It would seem, however, that the rate of growth since the war—from 800 engines a week in 1946 to over 5,000 a week today in their Marston Road factory—will be difficult to maintain.

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Development of Fisons

Manufacturers of fertilisers have a contact with the farming community closer than that of most other supplying industries. For this reason the remarks of Sir Clavering Fison, chairman of Fisons Limited, are especially valuable for those in the engineering industry who sell mainly to farmers. He was most definite and confident concerning the appropriateness of the measures taken by the Government to give the farmers "a much needed feeling of confidence in the future of agriculture."

The Fison group are also making insecticides through their subsidiary company, Pest Control, which they acquired some three years ago. They now operate what is believed to be the largest weed-killer factory in Europe and have a strong network of overseas companies. They have sold the engineering side of Pest Control's business to Massey-Harris-Ferguson, but the association with Airwork, through the Fison-Airwork Company founded two years ago, is going well and the systematic provision of an aerial spray service gaining ground. Recent developments in the laboratories of Fison's general chemical and pharmaceutical group, whose appropriations for research are described as "now considerable," have led to the development of several new products, including "Imferon," a new type of expanded P.V.C., named "Fi-Vi."

The development of the Group is very much on the lines one is beginning to expect from large companies with active research departments: it is highly unlikely that the products now in quantity production will figure prominently in the group's turnover 10 years hence. The bulk of it will come from new products to-day in the course of discovery and development.

Metals and Materials

TOUGHENED RUBBER FOR LIGHTWEIGHT BATTERY CONTAINERS

In the past, the term "hard rubber" has been applied to rubber compounds, with or without fillers and accelerators, vulcanised or cured with approximately 40 parts of sulphur to 100 parts of rubber. Soft rubber compounds contain sulphur in the ratio of up to 3 or 4 parts to 100 parts of rubber. Intermediate proportions of sulphur do not produce the results which might be expected and the compounds resulting from the use of sulphur in proportions between, say, 6 per cent. and 30 per cent., find no application. Thus, apart from some basically soft rubbers of high specific gravity carrying very high filler contents, there has been a gap in rubber technology in the range of hardness available in rubber compounds.

In recent years two methods have been developed to overcome this situation and to extend the range of rubber-based materials. In the first place, co-polymers of styrene, such as styrene-butadiene, are now available which, when compounded with rubbers and taken to the soft cure stage, yield a product of increased hardness and strength. The processing qualities are greatly improved and the product has a low specific gravity.

In the second place, past difficulties in physically combining phenolic resins and rubber have been overcome and new resins and techniques have been developed enabling semi-hard rubbers to be produced.

Toughened or semi-hard rubbers based on the above two types are now widely used in the form of shoe-soling, and flooring materials, factory work containers and a number of other useful articles.

For many years battery containers have been made of hard rubber of the conventional type using blends of raw and reclaimed rubber containing fillers and a high sulphur ratio. The containers are also made from various compositions based on coal-tar pitch, bitumen, and asphalt as binder, with asbestos or cotton for reinforcement. The main requirements of a battery container are: resistance to acids, heat, oil and petrol, and impact strength, rigidity, light weight and low cost.

The recent progress in rubber technology, outlined above, has led to the further study of the requirements of battery containers and it is stated to be now possible to improve on the impact strength and heat resistance of the hard-rubber containers while reducing their specific gravity and dimensions and still retaining adequate rigidity. Materials have been developed along these lines by the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, working under an agreement with the Richardson Company, Melrose Park, Illinois, U.S.A., and these materials have been given the name of "Im-Plast." They are produced under licence from the Richardson Company's patents but they have been modified by the General Electric Company to suit the requirements of the British market.

All the raw materials used for producing the new toughened rubber are carefully controlled and the processing is carried out on a plant designed to provide the maximum of automatic controls in timing and temperature. It is emphasised, in conclusion, that rigid tests for impact strength, hardness, acid resistance, and electrical and other properties, have shown that the new material produces high-quality battery containers and opens up the possibility of new lightweight designs for the future.

IRON-POWDER COATED ELECTRODES

It is well known that the coating on the covered electrodes used in the metal-arc welding operation is usually consumed more slowly than the metal core of the electrode. Consequently, the coating projects slightly beyond the core and thus directs the molten metal from the core on to the work; it reduces also the heat losses and increases the rate of deposition. The coating confers other benefits; it normally contains fluxing agents which lower the melting point and surface tension of the protective slag formed over the weld metal. Again, many coatings contain organic materials which, on heating, give off quantities of gas that envelop and shield the arc and molten metal and protect them from the surrounding air.

The use of iron powder in welding electrode coatings is not new in this country but it appears to have come into prominence to an increasing extent in recent years. It was interesting, therefore, to learn from a lecture delivered in London recently by Mr. D. L. Mathias, who is a welding consultant in America, that the iron-powder type of electrode had been introduced into the United States in 1935 but had been in industrial use for the last four years only. Mr. Mathias, who is visiting this country at the invitation of Powder Metallurgy Limited, Commonwealth House, 1-19 New Oxford-street, London, W.C.1, and Höganäs-Billesholms A/B., Sweden, referred, however, to the "phenomenal growth" which had taken place latterly in the application of iron-powder electrodes in the United States. These electrodes, he added, greatly augmented the rate of weld-metal deposition and increased the speed of welding. The iron powder was partially conductive in the region of the arc and this property reduced the length of the arc and also had a stabilising effect upon it. Furthermore, the iron powder reduced the spatter loss; consequently a higher welding current could be employed—hence the material increase in the linear speed of welding.

Two new specifications had been formulated recently by the American Welding Society, namely, E 6014 and E 6024. The first contained 32 per cent. of iron powder in its coating, and the second 50 per cent. The deposition rate, in lb. per hour, had been found to increase in direct proportion to the percentage of the iron powder contained in the coating.

One result of the increased use of iron-powder electrodes had been to improve the efficiency of welding apparatus in many works, as it had been found that full benefits from the new materials were only obtained with up-to-date equipment.

OIL-RESISTANT BELTING

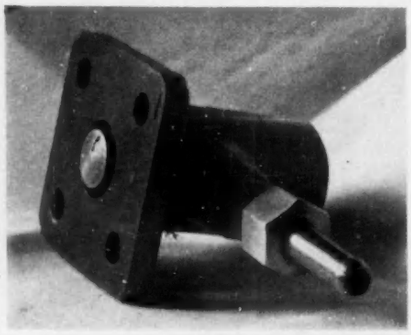
A new oil-resistant plastic power transmission belt is announced by R. and J. Dick, Limited, 4 M'Phail-street, Glasgow, S.E. Known as "Dixylon-Suplex," it possesses anti-static properties, is resistant to abrasion, even under very oily running conditions. The properties of high tensile strength, resistance to stretch and heat, found in the manufacturers' standard "Dixylon," are also present in the new belting, which is particularly suitable for high speed drives up to 10,000 ft. per minute, especially for small diameter pulleys and short centres. It is easily made endless in 15 minutes with simple tools, and the joint is even and flexible, ensuring smooth running.

Plant and Equipment

PNEUMATIC VIBRATOR

The " Blencut " rapper is a small all-purpose pneumatic vibrator that has been produced by the Blending Machine Company, Bond-street, Hockley, Birmingham, 19.

The base of the instrument, which is illustrated in the accompanying figure, is $3\frac{5}{16}$ in. square, and the overall height is $4\frac{3}{16}$ in. Operating at a maximum air pressure of 80 lb. per sq. in., it will deliver approximately 2,500 hammer blows per minute, and this number can be controlled by reducing the pressure. The use is for attaching to hoppers or containers where

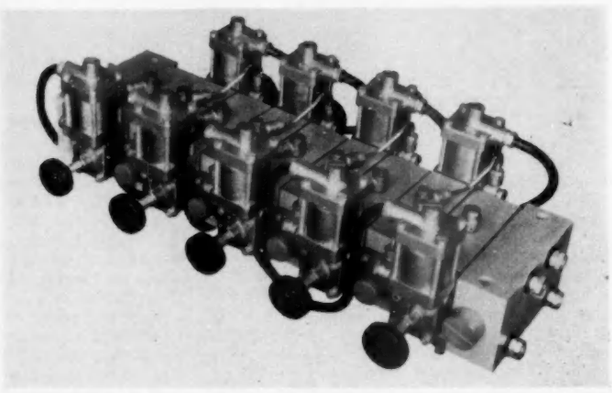


At a maximum air pressure of 80 lb. per sq. in. the Blencut rapper will deliver 2,500 blows per minute. A reduction in the pressure lowers the rate of vibration.

the material is liable to clog or stick to the sides, the vibrating action loosening the material and causing it to flow. They can also be fitted to formwork or shuttering to assist in the compaction of concrete mixes. The standard connection is for a $\frac{1}{2}$ in. flexible air line.

FEWER PIPES IN CONTROL SYSTEMS

Where a number of main control valves are used in the construction of pneumatically or hydraulically operated machinery, the problem of providing inter-connecting piping for supply and exhaust connections becomes acute, particularly where space is limited and the pipe size is relatively large. Also the user is faced with the necessity of expending material and labour in providing these inter-connections.



By mounting the 8 bank solenoid-controlled pneumatic unit as a packaged system, 15 inter-connecting pipes are eliminated from a control lay-out.

Baldwin Instrument Company Limited, Dartford, Kent, have produced a system whereby the control valves are grouped at a central point in such a way that the inter-connections are eliminated. The valves, which may be fitted with manual, mechanical, electric-solenoid, or pilot operating mechanisms, are supplied as a multi-point packaged unit. Any number of valves, up to a maximum of 12, can be embodied in a single unit. The supply and exhaust ports of all the valves are led into passages running the full length of the assembly. Screwed connections are provided in special end pieces, which also provide facilities for mounting the assembly as a whole. Each end block contains one supply and one exhaust tapping—these are common to all valves. Tappings in each individual valve body provide fluid take-off points for solenoid pilot heads, if these are used. Each main control valve is therefore an entirely independent unit when working.

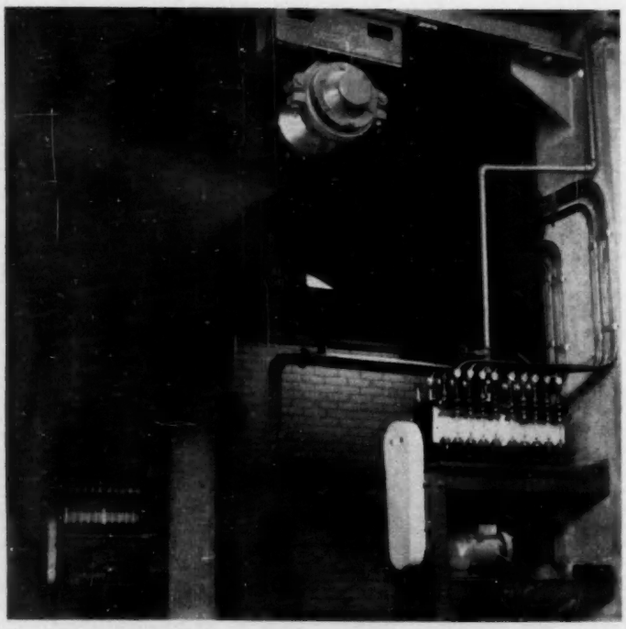
To install the unit, it is necessary only to connect the main air or oil supply to one end block, and lead the usual connections to each power cylinder. For pneumatic service, protective hoods are fitted to the main exhaust ports in each end block, and also to the exhaust ports of any solenoid pilot mechanisms that may be incorporated. For hydraulic service, the user must provide only one drain line back to the pump reservoir, solenoid drains being fitted integrally in each valve element.

The simplification that is effected by this type of packaged unit may be gauged from the fact that 15 connecting pipes are eliminated in the 8 bank solenoid-controlled pneumatic unit that is illustrated. The company say that the ultimate economy possible is indicated in the case of a 12 point double-solenoid-operated hydraulic unit, where the total number of inter-connecting pipes is reduced from 84 to 2, namely, a supply and a drain connection from the pumping set. No separate pilot supply piping is needed, as this is provided for by the tappings mentioned earlier.

At present the packaged units are available in the $\frac{1}{2}$ in. bore, 4-way pattern only. Any desired combination of operating mechanisms can be provided in the bank. In due course individual manifold sub-plate valves will be introduced.

MECHANICAL LUBRICATORS

An example of centralised mechanical lubrication is the installation at the Wolvercote Paper Mill, Oxford, provided by Wakefield Dick Industrial Oils Limited, 46 Grosvenor-street, London, W.1. For the lubrication of the front and back bearings of the 30 drying cylinders of the Millspaugh machine there are four DP50 mechanical oil lubricators; two are shown in the illustration. Each has 20 feeds, delivering through sight feed tubes. Each of the four is driven by its own electric motor. The system includes special outlet fittings adjacent to each of the bearings being lubricated, which will maintain a constant level of oil in the bearings, in addition to efficient oil filtering and water separating arrangements. For the felt roll bearings, four manually-operated grease lubricators pumping to 42 points have been fitted, and a separate system using a 16 feed DP50 lubricator has been installed for the calendar. Two of the latter feeds have been adapted for the high pressure lubrication of the torque relief system which is fitted on the bottom roll.



Centralised mechanical lubrication adopted at a paper mill.

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MEASURING WATER FLOWS

A water consumption meter designed for the measurement of widely varying flows has been produced by George Kent Limited, Luton, Bedfordshire. The " Compound " meter as it is called, supersedes the older Torrent Combination meter and, in the case of the 3 in. model, has a range of 500-1 with limits of error within two per cent. It actually combines two completely separate measuring units—one for high and one for low flows—together with an automatic changeover valve to select the one required. The mechanism is such that only one unit can register at a time.

The body contains four main components, the high- and low-flow measuring units, the changeover or pilot valve and the main valve. As the flow approaches the changeover point, the pilot valve starts to rise and restricts the flow through the top skirt which has previously passed all the water. This restriction helps to give instantaneous valve movement. When the valve is lifted, the passage opens through the bottom skirt, and the flow is diverted to the high flow unit which is the standard Kent Torrent inferential type. The low unit is the standard Master rotary-piston model. The 3 in. model starts to register at flows of 3 gallons per hour, and has a maximum recommended monthly flow of 4 million gallons. The maximum working temperature is 120 deg. F.

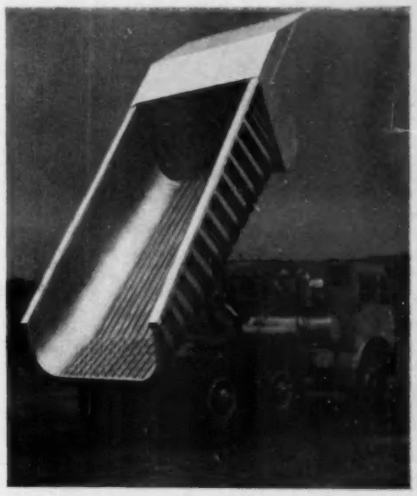
ALUMINIUM DUMPER

Unusual in the field of contractors' plant is a dumper of 10 cub. yard capacity fitted with an aluminium alloy body, shown in the illustration on the right. The use of aluminium has cut the body weight to half that of the normal steel type with an increase in carrying capacity of over 10 per cent. Following the normal practice of G. E. Neville and Sons, Limited, Nottingham-road, Mansfield, the builders, the body is of a bolted rather than welded construction in order to simplify assembly and field repairs.

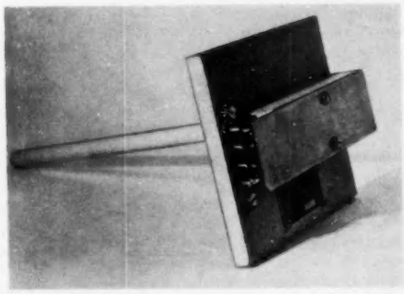
It is basically formed from extruded planks in Noral B.51SWP alloy supplied by the Northern Aluminium Company, Limited, Banbury, and these are turned through 90 deg. bends at 16 in. radius to form a U shape. These planks form the floor, sides and framing of the body, and are assembled by bolts passing through the front and rear flanges. The body is reinforced externally by the addition of extruded channels or "top-hat" sections, also in Noral B.51SWP, which are bolted to the stiffening ribs of the planks. The whole body is lined internally with $\frac{1}{4}$ in. Noral 26SWP plate.

Impact strips running the length of the floor are designed to give protection to the bolts used in assembly and to absorb some of the blows imposed during loading. Also, to relieve the chassis on impact loads, the steel body sub-frame is carried on 12 Metalastic rubber buffers, three at each corner, and the body hinge pivots, which are heavy steel linkages, are also attached to the top flange of the chassis frame by ultra-heavy-duty bushes. These linkage plates incorporate wearing strips that register with the chassis frame to control side-ways movement of the body. This linkage arrangement permits a full 60 deg. angle of tip to be obtained, and an adjustable screw is provided on the scow end of the sub-frame to trip a cut-off valve in the supply line to the tipper rams. Care has also been taken in the design of the side capping members, which are extremely vulnerable in a body of this nature; these capping rails, which can be removed as units for replacement or straightening, are in effect double inverted steel channels, one inside the other and separated by a rubber strip and rebound bushes, the inner channel being attached to the top of the body side.

This body weighs 2 tons 4 cwt., about half that of its steel equivalent and gives a yard more capacity; on this basis nine chassis with aluminium bodies could do the work of ten with steel bodies, and the saving would offset the greater cost of the aluminium.



Although the body is made in aluminium alloy, this dumper is capable of normal heavy duties. For half the weight, the body capacity has been increased by 10 per cent.



The sensitive element of this platinum resistance thermometer remains free from strain irrespective of temperature.

MEASURING 1,200 DEG. C.

For measuring temperatures from 100 deg. C. up to 1,200 deg. C. a platinum resistance thermometer with repeatable and stable characteristics has been introduced by C.N.S. Instruments Limited, 61 Holmes-road, London, N.W.5. It is particularly suited to control applications.

The thermometer consists of a re-crystallised alumina sheath, sealed at the lower end and containing the sensitive element. The top of the sheath is secured to an asbestos-composition mounting board with suitable connections for the thermometer and compensating leads. The sheath is 0·3 in. in external diameter by 6 in. or 10 in. in length in standard form, but other lengths can be supplied.

High stability has been achieved by an unusual form of construction, enabling a control accuracy of $\pm$ 1 deg. C. to be achieved at 1,200 deg. C. Long-term drift from the controlled temperature at this high level is within the accuracy of measurement of platinum/rhodium platinum thermocouples.

The standard sensitive elements, which have a cold resistance of 5 to 6 ohms or 9 to 10 ohms, are non-inductively wound on to a former which is separately supported from the sheath and slides into the sheath with minimum clearance, thus keeping the platinum wire element free from strain irrespective of temperature. The sensitive element remains undisturbed, and therefore provides stable operation at temperatures high enough to cause creep in the sheath.

The re-crystallised alumina is specified by the manufacturer to be impervious to all industrial furnace gases, including hydrogen, throughout the temperature range of the thermometer.

PRESS-SHAPING OF HEAVY STEEL PLATE

To meet the demand for shaped heavy steel plates used in their contracts for building nuclear reactor pressure vessels, Whessoe, Limited, Darlington, have installed a large hydraulic press. Made by Fielding and Platt Limited, Gloucester, the press has a capacity of 4,500 tons and handles plates 25 ft. long by 10 ft. wide. It was designed in co-operation with Whessoe engineers and other contractors to form a closely-integrated unit with the furnace and plate-handling bogie. The principal features of the press are tabulated below:

Working space available on moving table	12 ft. 4 in. × 26 ft. 8 in.
Maximum overall length of moving table	27 ft.
Maximum overall width of moving table over column guide brackets	17 ft. 3 in.
Number of main rams ..	11
Number of ejector rams ..	17
Maximum overall height of press above floor level	21 ft. 3 in.
Depth of foundation pit ..	31 ft.
Maximum hydraulic working pressure	4,750 lb. per sq. in.
Mean hydraulic working pressure	4,500 lb. per sq. in.
Minimum hydraulic working pressure	4,250 lb. per sq. in.
Total gross power of press at 4,500 lb. per sq. in. allowing for weight of moving parts	4,600 tons

The very large, thick steel plates used in the construction of nuclear reactor vessels require heavy machinery to shape them. This 4,500 ton hydraulic press has been installed by Whessoe, Limited.

Eight forged manganese steel columns locate and tie together the top and bottom tables, and the top table is supported by half collars in recesses on the columns; the design allows for adjustment of the top table to maximum and minimum daylight positions. A press crane, consisting of two electrically-operated hoist blocks on a travelling chassis can be traversed inwards on roller paths in the top table when tool changing is to be carried out. Normally, the crane is housed clear of the press on extension members. The moving table is actuated by eleven high-pressure rams, ten of which are bored axially to form cylinders for ejection rams. Seventeen of the latter are installed, with a combined power of 148·75 tons. They are operated either singly or in groups through joy-stick controlled valves on the control panel.

The press controls have been designed for ease of operation, the operator being supplied with complete information on press conditions. A novel feature of the control panel is a pilot-lamp system under a Perspex frame, the lamps forming a pattern corresponding in scale and position to the ejector rams. Integral marking strips fitted to the frame are set to indicate the contours and size of the plate being shaped, and the pilot lights enclosed within the area of the strips then show the ejector rams required for ejection purposes.

Water is used for both the high- and low-pressure circuits. For the high-pressure cylinders it is supplied under pressure by Fielding horizontal three-throw totally-enclosed pumps having a displacement of 35 gallons per minute at 4,480/4,780 lb. per sq. in., when operating at 540 r.p.m. The supply to the press is regulated by an air-hydraulic high-pressure accumulator system, consisting of eight forged steel bottles, six being for air and the remaining two for air and water. Two three-stage water-cooled compressors, each of 9·2 cub. ft. per minute displacement, supply the working air. There is a pressure variation of 10·55 per cent. when the useful water capacity has been drained out, the variation being arranged as 5·55 per cent. above working pressure at maximum water level, falling to 5 per cent. below at minimum water level.

Low-pressure water, for the ejector air-hydraulic accumulator, is at 450 lb. per sq. in.; a low-pressure pump under electronic control supplies the water.

Management

Weekly Survey

Business Sites in Vancouver

A report on the progress being made at the Annacis Industrial Estate was given in London last week on the occasion of the presentation of a film "Opportunity to Let," which shows the growing market for goods of all types that exists in British Columbia, Canada. To date 36 firms are now established at Annacis, of which three are of British origin. The most recent British firm to go there is Vickers-Armstrong (Tractors) Limited, who have established a depot for the distribution of their crawler tractors and the supply of spare parts as well as a base for an after-sales service. The capital investment represented by all the companies there is now over 30 million dols., the greater part of United States origin.

Annacis, it will be remembered, is a 1,200 acre island in Fraser River, adjacent to Vancouver. It is being developed by Grosvenor-Laing (B.C.) Limited, the joint organisation formed by the two British firms, Grosvenor Estates and John Laing and Son, the civil-engineering contractors. The island has been laid out in a series of factory plots; roads, drainage and services have been laid. By agreement firms may either build their own plants or rent the land and buildings. Well sited within a few miles of the United States border, Annacis is at the centre of a net of transport routes by sea, air, road and rail. There is abundant power, cheap water and natural gas; piped oxygen is also laid on.

The venture was initially started to enable British firms to get established on the western seaboard of North America. It is now two years since the estate was officially opened: in that time plots have been let and a number of modern factory and office blocks built to the requirements of the tenants; standardised blocks can also be erected quickly for firms who want only limited accommodation. Further details can be obtained from Grosvenor-Laing either at Annacis Island or from their British address, 4 Regent-street, London, S.W.1. Applications to hire the film, which is in colour and runs for 28 minutes with a commentary, should also be made to this latter address.

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Rationed or Rationalised Water?

There is an urgent need for more water. Consumption of water in the United Kingdom has risen from around 1,500 million gallons per day before the war to not far short of 2,500 million gallons per day at the present time. The rate of increase in consumption is also accelerating. Thermal electricity stations, for example, are at present using 600 tons of water for every ton of coal consumed, and atomic stations may use far more than conventional power plants. The chemical industry takes about 820 million gallons per day at present, and it has been estimated that by 1966 chemical manufacturers will need over 1,200 million gallons per day—or almost half the present total water consumption in all uses. The iron and steel industry takes over 350 million gallons per day at present, and paper manufacture needs a further 200 million gallons per day. Their needs are also expanding.

The British climate ensures an adequate supply of water, but the difficulty of course lies in tapping these supplies. The building of water works, reservoirs and ancillary equipment entails a great deal of expenditure. Between 1948 and 1955, for example, the water industry spent about £230 million on capital works, and even this was considered inadequate to overtake wartime arrears, let alone as an investment to meet the future growth in demand. When an industry faces a capital shortage, there is usually a natural tendency to co-operate and to concentrate effort. Most water undertakings are however in the hands of local authorities, and there is a strong element of local pride which often overrides economics. There are still nearly 1,250 water concerns in this country, and more than half the water supply is in the hands of upwards of 1,000 small undertakings. There is obviously a pressing need for rationalisation to ensure an adequate water supply for the future.

The Government is fully aware of the need, but so far has been unwilling to enforce the compulsory powers conferred by the 1945 Water Act. The Minister of Housing and Local Government, Mr. Henry Brooke, continued his policy of patient nudging last week when addressing the British Waterworks Association, although he reminded the industry that he has compulsory powers available, which he will not hesitate to use in case of unnecessarily delayed grouping of undertakings. He said that he was on the whole satisfied with regrouping progress, but that the prestige attached to owning their own waterworks by some local authorities was still hampering rationalisation. There has however been an encouraging tendency towards co-operative planning between different undertakings. The Hanningfield water scheme, costing over £5 million, was carried out jointly by the Southend and South Essex Water Boards, while the Durham County Water Board and the Sunderland and South Shields Water Company are jointly sponsoring a £9 million scheme. There have been other examples of this welcome trend over the past year or so. If the water industry is to meet the growing demands for its services, much more of the same spirit of co-operation will be needed.

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Britain Sells to Germany

As one way of curing the trade surplus Dr. Erhard has been almost begging the Germans to import more. How has Britain benefited from this inspired anxiety for foreign goods? The short answer is very nicely, thank you. Total United Kingdom exports to Western Germany rose by over one-third from £74 million in 1955 to £98 million in 1956. Although the German engineering industry is enjoying a minor boom, some British manufacturers of machinery and durable consumer goods have had a spectacular rise in sales there. British Diesel engines have increased their exports by six times and now supply one-fourth of the engines imported. Perkins of Peterborough have done especially well, in spite of the competition of Klockner-Humboldt-Deutz A.G. with their 27,000 workers. Imports of British electric washing machines have risen by 50 per cent. Although Germany manufactures these products herself, the keen exporter can find gaps that can be filled with advantage.

The fall in the surplus in the latest returns of German foreign trade does not mean that the flow of imports will be cut off. On the contrary, this fall is taken as a sign that trade policy is working properly. Another important factor is that both wages and the standard of living of the German worker are now going up. National policy and consumer demand should combine to help Britain sell more goods of the right quality and price in the German market for some time to come.

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Depression Over West Wales

The plight of west Wales has been much in the news lately. Despite Government assurances that there is no intention of allowing the region to become a depressed area, the closing down of hand-operated sheet steel and tinplate capacity there has certainly fostered an air of depression. During the last year 13 tinplate works have closed and 8 tinplate works are now left operating 26 hand mills. It has been suggested that by this time next year there will be no hand mills left in the area. This is due to widespread modernisation, which means that new mills elsewhere are able to utilise raw materials more effectively, and to the slackening of demand for hand-made tinplate. Meanwhile, Richard Thomas and Baldwins Limited have closed two steelworks near Swansea, which will mean unemployment for 1,000 operatives, and Stewarts and Lloyds Limited tube mill at Swansea will close on December 20, adding another 400. Total unemployment in west Wales was just over 4,400 in October, 800 more than in the previous month and 2·2 per cent. of the working population. Apart from Scotland (2·3 per cent.), this was the highest unemployment rate in any part of Great Britain.

The two deputations from west Wales which visited the Board of Trade recently both had the same suggestion to make to revive activity in the area. Captain Leighton Davis, who led a deputation from the Welsh Board for Industry, put the case for locating the controversial fourth integrated steel plant in west Wales rather than in Newport. A delegation of local authorities, led by the Town Clerk of Llanelly, Mr. Selwyn Samuel, made the same plea, and further thought that it was necessary to keep many of the hand mills open until the new plant was in production. The latter suggestion might seem to be of some moment if it were not for the current slackened demand for tinplate. The Iron and Steel Board estimated in August, 1957, that there would be a deficit of 900,000 tons of sheet and tinplate by 1962 if all the hand mills were closed, but this figure is regarded as covered by the fourth integrated plant.

At the interviews the Government could still give no decision on the location of this integrated plant. This scheme, which will cost £160 million, is supported by the Iron and Steel Board for immediate development. The British Iron and Steel Federation and Richard Thomas and Baldwins (the company which will own the new plant wherever erected) have had second thoughts about immediate construction. The matter is still in abeyance, and a decision is not expected for several months yet. In view of the present difficulties in west Wales, it is just possible that the location of the plant will again be reconsidered. Richard Thomas and Baldwins, however, favour Newport, since the new plant would then fall in with their expansion plans at Ebbw Vale, and all things considered development there is more likely. Unemployment in west Wales is not likely to be materially solved by the siting of an automated steel plant in an area where the redundant labour is on the whole old, skilled and not easy to train in new techniques. The introduction of light industry to give a diverse hinterland to Milford Haven further west has a good deal more to recommend it.

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Standards for Overseas Reference

The addresses overseas at which sets of British Standards can be inspected are given in a new booklet issued by the Federation of British Industries, 21 Tothill-street, London, S.W.1. The publication, which is entitled *British Standards Reference Sets: Overseas Address List*, has been prepared primarily for the use of overseas scholars of the Federation, when they return to their own countries, but it should be also of value to engineers practising abroad. The various foreign countries and territories, and British dominions and colonies are arranged in alphabetical order, commencing with Aden, Albania and Argentina and ending with Yugoslavia and Zanzibar. Under each country are given the full names and postal addresses of holders of sets of the Standards.

There is no need to stress the wide field of technical activities covered by British Standards nor is it necessary to enlarge on their value to engineers. The cost of the booklet is 2*s.*, and it is obtainable from the address given above.

Research and Development

AUTOMATION ENGINEERING

STEPS TOWARDS AUTOMATIC WELDING

By F. Hirschmann, A.M.I.E.E., A.M.INST.W.*

In this article, the automation of a familiar process—inert-gas arc welding with filler wire—is described, with emphasis on the solution of typical problems that arose and that may have an application for other schemes.

Automation, as seen by the engineer who has to carry it out, is only seldom spectacular, like the design of an automatic factory. More often it involves a scheme which is limited in its scope and in the amount of the money that can be saved by the automation and that may be invested in the necessary apparatus.

In developing equipment to suit a particular task, it is often the most difficult part of such development work to find a starting point, to isolate as a first step one single feature of the process and to guide it automatically, so that the automation of other features can follow. It appeared worth while to discuss the automation of an electric arc-welding procedure with the aim of showing how the steps of the automation were chosen, and how the solution of the problems occurring was achieved; it is hoped that this discussion will offer some hints for other—perhaps more involved—processes.

Electric arc welding by hand is a complex procedure. It is one of those skilled trades where the result of the work—its appearance and its quality—depends on the way the operator co-ordinates several movements, all done at the same time, while he is watching the workpiece and judging the result of his actions. The operator has not only to traverse his welding torch in the direction of the welding seam, he has also to move the torch downwards or upwards in order to strike the arc and to keep it burning at the right length so that he obtains the desired penetration of the workpiece, adding, in many cases, a lateral movement of the torch. He often feeds at the same time with his left hand a filler wire into the arc. One or more foot switches may be provided, by which the welder has to switch on or off the mains current, the shielding gas, an ioniser or some means of altering the current, in order to avoid a crater at the start or end of the seam. There is a school of welding-plant designers who add a switch or two on the torch handle, or on the handle of the shield, and the welder is expected to operate these by his unoccupied right or left thumb. This does not exhaust the list of the welder's duties: he may have to open and close a valve for the cooling water of the torch, operate a few levers on the jig (at the right time and in the right order) and perhaps use an otherwise unoccupied foot to control the rotation of a turntable, which holds his workpiece during welding.

* Consulting Engineer.

It is clear, from this somewhat abbreviated enumeration, that the comprehensive automation of a full production cycle can, with arc welding, neither be achieved by mechanisation based on a fixed programme, which makes one action automatically follow the next, nor by a simple process control which takes care that one or more particular aspects are independently looked after and maintained.

Fig. 1 shows an attempt to compile those influences which may be responsible for the success of an arc weld made in inert gas with a refractory electrode and an additional filler wire. The connecting lines indicate the different effects in the arc and the weld which the characteristics (and adjustments) of the torch, welding plant, jig and work piece may have on the weld. The diagram gives only an approximation of all the physical, electrical, chemical, metallurgical and mechanical effects which may occur and be superimposed on each other; any attempt to give a complete picture would only produce what the publicity people of the insurance companies advertise as a "Tibetan Ghost Trap."

The solution of our problem can be prepared for an initial attack if we visualise a steady state condition. With hand welding such a condition will occur if the welder has only to correct the arc length by moving the torch up and down. The automatic performance of this movement could be a starting point for the automation.

CONSTANT ARC LENGTH

One of the practical production problems which caused this work to be done was the welding of light-gauge sheet-metal cylinders, such as the circumferential and longitudinal seams on the flame tubes of jet engines. With the circumferential welds the torch was expected to move up or down a small fraction of an inch, just sufficiently to compensate for any eccentricity in the mounting of the workpiece on the rotating welding jig. Light-gauge welds, especially on a material like titanium, with its low heat conductivity, are very sensitive to any variation of the arc length, if the penetration has to be just right, and it is difficult to set up the rotating jig to the required accuracy. With the longitudinal welds a torch movement of the order of a few inches may be necessary to follow the curved or tapering outline of the tube, but the accuracy of the arc length has to be the same as for the circumferential welds.

It was shown by a feeler gauge, mounted on the top of a welding torch, that the vertical deviation of the torch had to be kept within 0·003-0·004 in. in order to guarantee optimum results, limits hardly obtainable by hand welding. The actual length of the arc is 0·03 to 0·04 in., or more; in a few cases very much less. The work described was initiated by firms of the aircraft industry, not so much with the aim of saving working hours or increasing productivity, as in order to improve the quality of the product.

The problem set as the first step of automation was, therefore, the maintaining of a constant arc length, within very close limits, but with the possibility of setting it within a wide range.

CONTROL AND FEED-BACK CRITERIA

Arc Voltage.—It is not practicable to measure the arc length directly as the distance of the electrode tip from the foot point of the arc on the workpiece surface, at least not while the arc is burning. But any change of the arc length will cause a change of the arc voltage and of the arc current, following the static characteristics of the welding plant. The process, for which Fig. 1 was compiled, works best with a plant on which the current alters as little as possible in the range between arc voltage and short circuit (very steep characteristic), because that reduces the risk of burning holes into the seam. On this basis the arc voltage was the right criterion to be chosen for the arc-length control.

This raised the question of the range of arc voltages which were to be maintained in order to achieve the desired range of arc lengths. A few tests made did not quite agree with the data given in the available literature; it was soon found, when work on the control system proceeded, that the actual arc voltages (arc voltages down to 4·5 volts were measured by the author) were well below the sum of the theoretical cathode and anode drops, with nothing left for the drop in the arc column. It was some consolation that recent publications confirmed this and stated the necessity to correct the established theory of the electric arc. This experience is probably typical for this kind of automation work: it is often necessary to start from "scratch" even when so-called physical facts are involved.

Torch Movement.—Just as important as the criterion for the control is that for the feedback, on which a decision has to be made at the start of any scheme of automation—even if the automation engineer hopes every time, in vain, to get away without it. In our case the negative feedback, which indicates the response of the

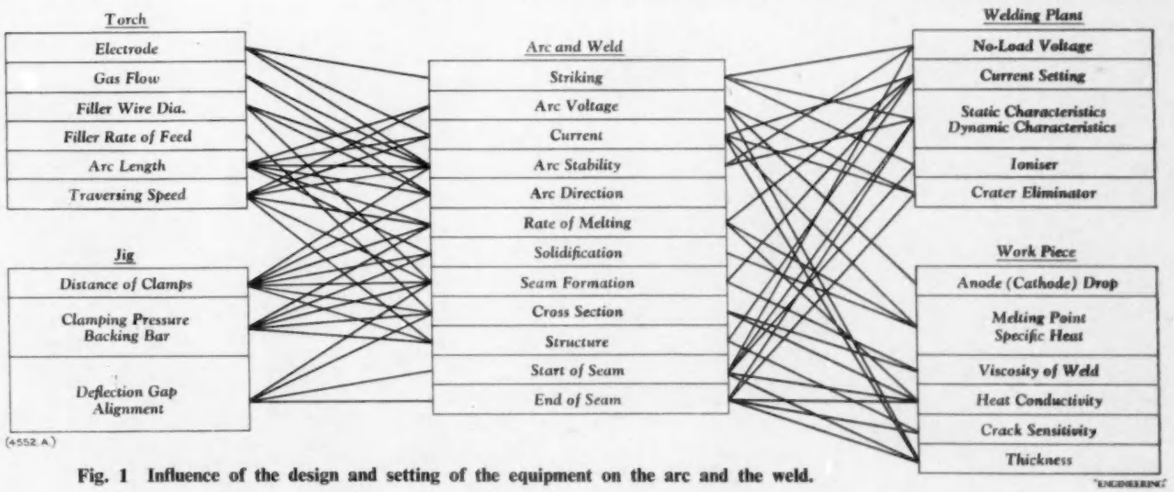

Fig. 1 Influence of the design and setting of the equipment on the arc and the weld.

Continuing

Research and Development

control, had to be taken from the actual movement of the torch, its speed and its acceleration.

ELECTRIC SERVO—NO THERMIONICS

The choice of an electrical solution for the servo system appeared to be a natural one, as the control impulse was to be given by an electrical quantity. The possibility of using available components without waiting for the completion of special designs would have given weight to the choice of a hydraulic system, which is normally preferred for machine tools. The decision, however, was made in favour of electrical control, mainly because it lends itself easily to the introduction of feedbacks by additional voltages and/or current (of the possible need of these, nothing definite was known at that stage) and also because it was rightly expected to be less costly on the basis of at least equivalent performance.

The design data for the automatic control were given by the working conditions of the welding torch. An inert-gas arc-welding torch with water cooling as used for heavy-current welding might weigh from 30 to 40 lb.; the torch has to be lifted at a speed equal, or superior to, the vertical component of the traversing speed. Practical figures for the lifting speed were found to be of the order of up to $\frac{1}{4}$ in. per second. The power of an electric drive for lifting such a torch is mainly spent in the gearing; it could be assumed that about 30 to 40 watts would be required.

The control power which was available for the arc-length control was determined by another consideration. It was thought that a voltage difference of the order of 0·1 volt should start the correction of the arc length, but it was unavoidable that very much higher voltages might enter the control circuit.

The current which flows through the control circuits at such a comparatively high voltage must not be more than a small fraction of the arc current, as it would otherwise upset the welding arc. The control current which, with the low voltage of, say, 0·1 volt available for normal control impulses, causes the working of the controls must then be very low indeed; the available control power was found to be of the order of a fraction of a milliwatt. A very high amplification was required to obtain, from that control input, the output of, say, 40 watts which was required for the servo motor.

The amplification could have been obtained by a wattmetric relay (this was, in fact, as was found later, tried by others) but such a relay, if sensitive enough to obtain the necessary response, might fail under the conditions of a welding shop. All relays depend on the movement of a contact and a purely static device was thought to be preferable. A control by relay has another more serious disadvantage; the intensity of the action taken is constant, and does not vary with the intensity of the control impulse.

Electronic valve amplifiers are, not quite without reason, subject to prejudice, and the feature of a control equipment to be " no-valve " is still a good sales point. The works' electrician is very often not able to cope with the servicing of an equipment with valves, or at any rate the management hesitates to hand it over to him. The question of using valves (or " thermo-electronics ") in automation is therefore a rather controversial subject: the future automation of industry may quite likely be done to a large extent without them.

The magnetic amplifier appeared to be the right solution for the problem of the arc-length control, especially from the point of view of the user. The magnetic amplifier is a static apparatus with a comparatively simple circuit, with components which can be exchanged very easily if necessary; it lends itself to the incorporation of additional control impulses or to other modifications, which in the development of a new automation process are invariably required at a later date. The output of the magnetic amplifier can be made proportional to the control input, a feature which is very useful for the rapid following of profiles.

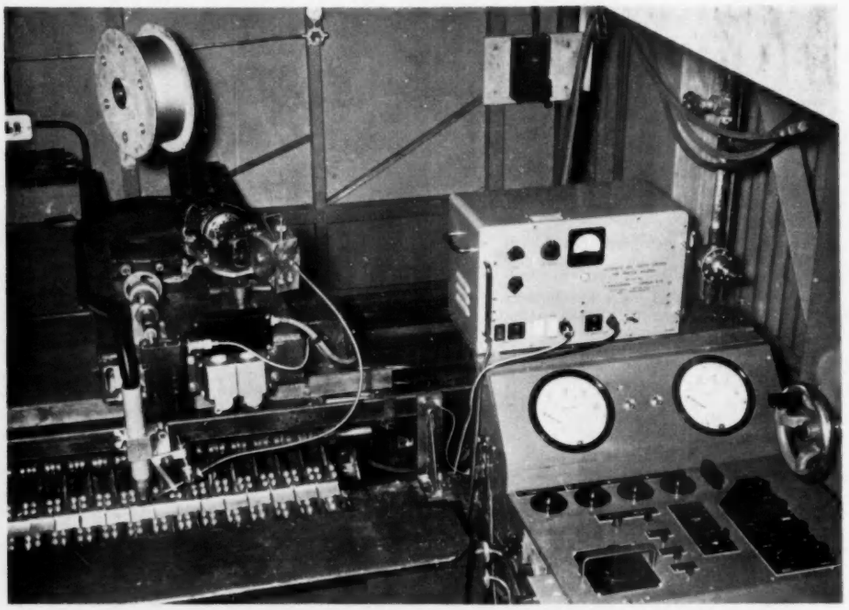

Fig. 2 Automatic arc-length control in a laboratory set-up.

Last but not least, the magnetic amplifier is by much the cheaper solution as far as the cost of the components is concerned. It has, of course, one disadvantage; its design can be (and this is an under-statement) very tedious and awkward indeed, but this is a point which does not concern the user.

The required power amplification, of the order of 1 to 1,000,000 and more, could be obtained in a single-stage magnetic amplifier with the required fast response, using toroidal transductor elements and special rectifiers; the amplification could, if necessary, be increased by an additional transistor stage.

The design programme of the electrical servo system was now practically settled. The arc voltage had to be compared in a voltage-sensitive circuit with a set voltage which reproduced the arc length desired, and the current produced by a (positive or negative) voltage difference had to be introduced into a push-pull circuit of two magnetic amplifiers, from which it was to be passed to the electric actuator of the torch. As actuator, a fractional horse-power direct-current motor with two field windings could be used.

AUTOMATIC ARC-LENGTH CONTROL

Fig. 2 shows the installation of an automatic arc-length control, with a control cabinet containing a potentiometer circuit for setting the required arc voltage and the magnetic amplifiers, and with the actuator for the torch. The arc-length control was tried out on a laboratory set-up designed by the user; it included a welding jig with a traversing gear (driven by the lead-screw of a lathe), a filler-wire feed and a control panel, with press-button switches for the different operations and a remote setting for the welding current.

The vertical movement of the welding torch

Fig. 3 Torch actuator.

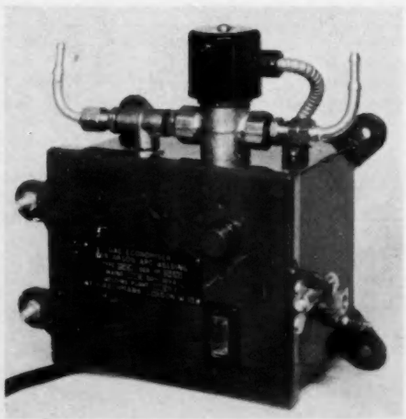

Fig. 4 Gas control.

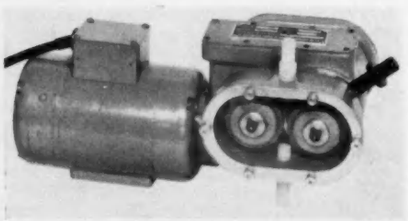

Fig. 5 Filler-wire feed.

under the influence of the automatic arc-length control was checked by a feeler gauge, while the arc voltage itself was continuously recorded. It was soon found—again a typical experience for this type of automation work—that the arc voltage is not always constant, even for a constant arc length, and an effort to keep the arc voltage constant would not always be helpful. An oscillograph will show fast variations, which the automatic control cannot follow (nor must it do so) without causing hunting; furthermore, the arc voltage between the cold electrode and workpiece is higher, but goes down with the heating up.

Another difficulty arose, again a typical one: The voltage fed into the controls differed from the arc voltage, when such a difference was not at all suspected. It needs only minor modifications to take care of such details in the control scheme; but a set-up with means for testing and examining performance as accurately as possible can be vital for the success of a complex automation scheme.

TABLE—*Components of a Scheme for Automatic Welding*

Component	Function	Design features
Torch actuator (Fig. 3)	Moves the torch up and down like the hand of a welder	A 5,000 r.p.m. 50 watt reversible geared motor drives a ram over a nut and a threaded screw, at a speed of up to 0·25 in. per sec. Ball bearings and ball bushings give rigid support to the ram, which can lift up to 100 lb. Electric braking guarantees stopping within less than 0·001 in.
Gas control (Fig. 4) ..	Starts and stops the supply of shielding gas. Prevents welding without gas, or oxidisation of a hot electrode	A solenoid valve in opened when the welding plant is switched on, but is closed by a timer with 30 seconds delay. A gas-flow control switch disconnects the welding plant if the gas supply fails.
Filler wire feed (Fig. 5)	Feeds a filler wire into the arc	A reversible low-voltage direct-current motor with Ward Leonard control and electric braking drives two feed rollers, adjustable for wire from 18 s.w.g. up to 10 s.w.g. with quick-release lever. The rate of feed can be set between 6 and 120 in. per min.
Traversing of the torch (Fig. 6)	Moves the torch along the seam ..	A motor similar to that of the wire feed drives the torch carrier over a lead screw and nut at a speed adjustable between 4 and 40 in. per min. The torch carrier acts on limit switches in the motor circuit.
Control of actuator, feed and traversing (Fig. 7)	Controls striking and torch withdrawal. Keeps the arc length at an adjustable value. Starts and stops the filler wire feed and the traversing	The current produced by the difference between the welding voltage and a pre-set voltage is passed through a push-pull magnetic amplifier, the output of which enters the torch actuator. The established arc starts the filler wire feed and the torch traversing.
Current supply (Fig. 8)	Starts the arc. Supplies the welding current, adjustable between 6 and 150 amps. Reduces the current smoothly near the end of the seam.	A 3-phase transformer feeds a transductor controlled rectifier, all oil-immersed. An adjustable crater eliminator with timer is controlled by a limit switch on the traversing gear. A high intensity spark oscillator causes instantaneous arcing, but fades out afterwards. The front plate can be taken out, to permit remote control.

TOWARDS COMPLETE AUTOMATION

The arc-length control had to be extended in two directions in order to form a basis for a comprehensive automatic welding scheme; it had to cover not only the steady-state condition, but also the start and finish of the weld, and it had to guide the other functions of the complex procedure. The first part of the problem proved to be easy (hard to say, now, if by intention or by chance): the arc-length control automatically started the arc, provided that the usual ioniser of the inert-gas welding plant bridged the gap to the workpiece, and it also withdrew the torch at the end of the seam. The transition from the striking movement of the torch to the steady state could be used for starting all those actions which had to come in at this point, such as the traversing motion and feeding the filler wire into the arc

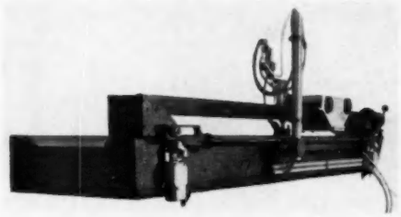

Fig. 6 Mechanism for traversing the torch.

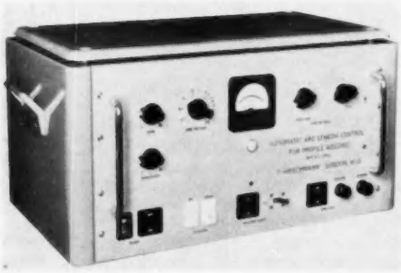

Fig. 7 Control of torch actuator, feed and traversing.

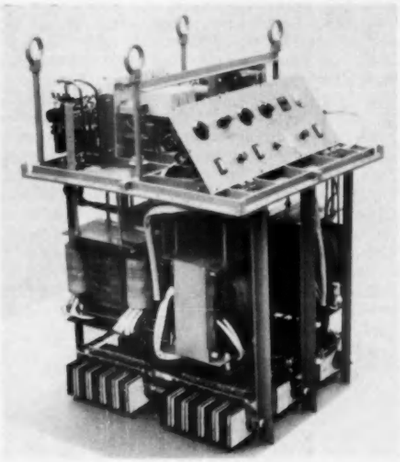

Fig. 8 Current supply unit.

The author was talking recently with a friend who had been building an electric railway for his children, with electric switches and signals, automatic train braking, etc. He intended to build a control, with uniselector switches, which would make it possible to select complete routes for the train; and then he thought again: one couldn't really play with such a railway. Some automation schemes seem to stop at this point which just leaves the operator the chance to play with his toy.

Automation can have only one meaning: a single press-button must start the whole process, which will stop on its own after its completion. This does not mean that the machine can work without an operator; on the contrary, many automatic machines, and the arc-welding machine will probably always be one of them, need an operator of high skill.

The complexity of the welding process (and probably of many others) makes it nearly impossible to adjust everything in advance; the automation scheme has to incorporate means for influencing nearly every aspect while

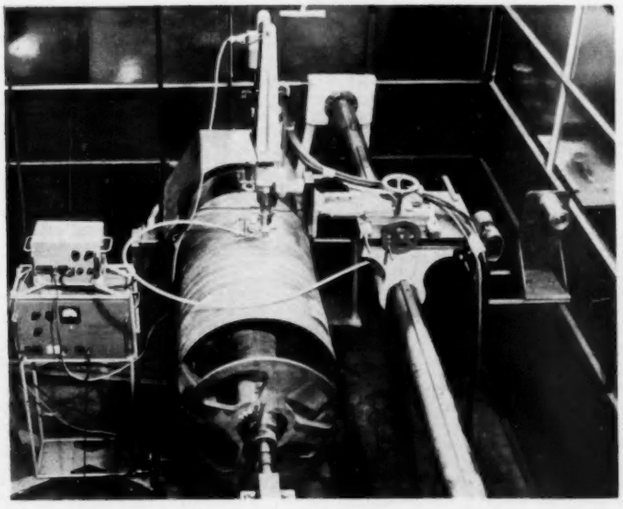

Fig. 9 (left) Automatic arc-length control and filler-wire feed in a welding shop.

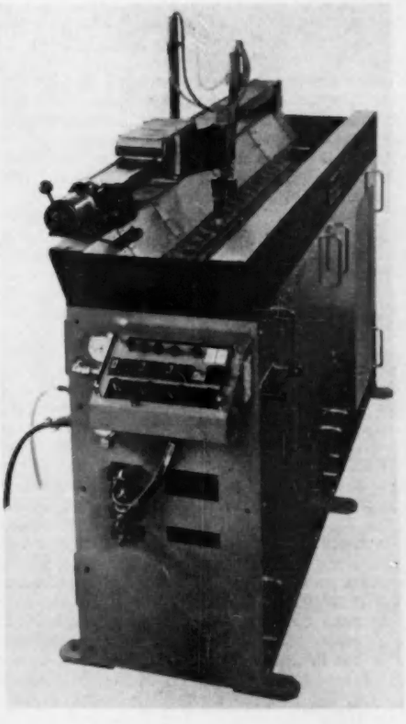

Fig. 10 (right) Automatic arc-welding machine for longitudinal seams.

Continuing

Research and Development

the welding is in progress, and in a way which maintains the chosen setting for the following repetitions. It is obviously not easy to achieve this result if the operator has to run along a moving torch carriage to alter its speed setting, or that of a wire feed, and has to walk back to the welding plant to alter its current setting. It is therefore necessary to concentrate all the controls and to arrange them in a clear way; the operator should have before him those knobs which he may have to turn, and the buttons which he has to press, together with a few indicator lamps, which confirm the completion of the command given.

It is wrong in principle to put in front of the operator a few square yards of over-sized instruments (pretty as they may look), only to prove to him that automation works. The author was recently asked if he could provide for an indicator which would show the variations in the speed of a torch trolley; welding generators are often equipped with an ammeter, because the current goes down when the machine warms up, and other equipment may react to mains voltage variations. The necessity to instal such instruments means that the automation has failed; the remedy is not an instrument and a hand adjustment but a constant-speed drive (in the above case a lead screw with magnetic amplifier control), a machine with a constant output (such as a welding rectifier of suitable design), a constant reference voltage (given by a constant voltage transformer), etc.

The extensive design work which was initiated by the automation scheme is illustrated in Figs. 3–8, which show some of the special equipment which had to be developed to fit the purpose. Details of the equipment are given in the table. The co-ordination of the control processes begins with the switching-on of the mains supply and the auxiliaries (inert gas), leads to the initiation of the process (striking the arc), the transition to the steady state (switching on wire feed and traversing) and its maintenance (arc-length control), and passes over the fade-out period (crater eliminator) to the termination (switching off current, wire feed and traversing, withdrawal of the torch, switching off gas). All press-buttons and other means of adjustment are suitably interlocked; the operator of an automatic plant will not consider it a crime to press the wrong button (as he would using the wrong lever on a milling machine), and a faulty operation must be automatically excluded.

The scheme is not complete, and additions are being made to it while this article is being written; one of them is a device to keep the torch in the centre line of the weld, another a special attachment for use with alternating-current welding of heavy aluminium plate, etc. The newly-developed components are, on the other hand, already used for applications which have no connection with the subject of automatic welding. Fig. 9 shows the installation of some of the equipment in a welding shop.

INTEGRATED SCHEME

The final aim of an automation scheme must be the completion of the job by a single machine, without any attachments, annexes or afterthoughts. Fig. 10 shows a machine for the welding of longitudinal seams on light-gauge sheet fully automatically and incorporating features which have been discussed. This is a machine built for a special job; other machines are now on the way which have the same wide range of applications as any other universal machine tool.

Conclusion.—It is only fair to admit that the actual development of the equipment for automatic welding did not always take place in the logical order in which it has been sketched. The work on some of the components had to be started before a proper specification was known, and there were quite a few modifications.

Automation—as against mechanisation—is a comparatively new trade, and the majority of its members are still apprentices; the author may be allowed to claim this as an excuse for giving this report of his own limited experience.

Acknowledgments are due to D. Napier and Sons, Limited, for permission to publish the photograph of Fig. 2, and to the de Havilland Engine Company, Limited, for the photograph of Fig. 9. The rectifier shown in Fig. 8 was designed to the specification of Rolls-Royce Limited. Some of the features described are the subject of patent applications.

TOO MANY INSTRUMENTS BAULK SUPERSONIC TESTS

" Satisfaction in an unusually well-harmonised pilot's aeroplane at all speeds; frustration in the continued difficulties experienced in navigating without adequate navigational facilities; embarrassment over inability to carry out tests at the speeds required without causing shock-wave incidents "—these are the main impressions left by the development programme of the English Electric P1 supersonic aircraft on the chief test pilot, Mr. R. P. Beamont, and the concluding words of a lecture on " Techniques and Procedures in Supersonic Flight Testing " which he gave recently to the students and graduates of the Royal Aeronautical Society.

The picture presented by Mr. Beamont of the high-speed test pilot's difficulties in conducting a comprehensive test programme in the environment of the United Kingdom is disconcerting. The problem is to reconcile the regulations limiting supersonic flying, and the " creeping growth " of airways and control zones in which test flying is not permitted, with the relatively large distances covered in short spaces of time by the high speed aircraft, accentuated by the difficulty of navigating a fast aircraft with the available airborne and ground aids. The problem is particularly severe when reheat is in use and the aircraft's endurance is extremely limited; such an operation has to be planned precisely to ensure that the aircraft can get back to base, that it does not encroach on restricted flying areas and that shock-wave " incidents " are confined to sea areas.

Because traffic on the V.H.F. fixing networks is heavy, when obtaining a " fix " a time delay averaging some 2 minutes elapses—during which the aircraft has covered up to 50 miles. All other forms of navigational aid available for the P1 test programme were equally unsuited to a fast aircraft. It is reassuring to learn that this does not apply to service conditions. So far, however, R.A.F.-type facilities have not been available for the test programme.

Even with adequate navigational aids test-flying problems are still formidable in the congested space over this island of erratic climate; and it seems increasingly probable that, if the development programme is to be carried through in reasonable time, flight trials will have to be conducted overseas.

ULTRA HIGH FREQUENCY TELEVISION

There remains only one part of the spectrum for new broadcasting stations—the ultra high frequency bands. The resulting trend towards the use of higher frequencies is exemplified by the B.B.C.'s sound programmes at about 90 Mc/s. The frequency of 2LO, in 1922, was about 0·8 Mc/s.

The use of higher frequencies complicates equipment design because the interaction between components becomes pronounced at high frequencies. In addition, the influence of the atmosphere on signals is not sufficiently well-known for systems to be designed without full-scale propagation tests. Yet as the problems are solved, congestion can again be expected. Television is particularly difficult, requiring a wide range of frequencies at each station. Should high-definition television be introduced, each transmitter will need an even larger range.

The allocation of specific frequencies for specific services is a matter dealt with by international conferences. An important advisory body at such conferences is the Comité Consultatif International Radio of the International Telecommunications Union. At Moscow next year there will be a meeting of the C.C.I.R. to discuss standards for television in Bands IV and V. It is likely that Britain will be the only European country with practical experience of high power television transmissions in this band.

Bands IV and V were allocated to television at the International Radio Conference at Atlantic City in 1947. But their use for normal services has been confined to America. The v.h.f. and u.h.f. bands allocated to sound and television in Britain are as follows: Band I—41-68 Mc/s. used for B.B.C. television. Band II—87·5-100 Mc/s. part used for B.B.C. sound programmes. Band III—174-216 Mc/s: part used for I.T.A. television. Band IV—470-585 Mc/s. Band V—610-960 Mc/s. The first three are referred to as very high frequency, the other two as ultra high frequency.

High power test television transmissions are now being radiated at 654·25 Mc/s. from Crystal Palace. The transmitter and aerial equipment is being hired by the B.B.C. from E.M.I. Electronics Limited, Hayes, Middlesex. Details of the tests were mentioned on page 621 of ENGINEERING, November 15.

The B.B.C.'s London region television transmissions originate from Crystal Palace. By having the u.h.f. transmitter at the same site, the B.B.C. are able to make a direct comparison between the propagation of television signals in Band I and in Band V.

The u.h.f. vision transmitter has a power of 10 kW at peak white. The sound transmitter has a carrier power of 2½ kW. Operation is possible anywhere within the frequency range 470-960 Mc/s. Low power modulation is used in both sound and vision channels and Eimac 3K50000LF klystrons are employed in both audio and video final stages. The klystrons use three external cavity resonators and operate as linear amplifiers with a power gain of about 100. They are driven by a modulated amplifier stage operating with a cathode modulated circuit. The output of the transmitters is combined in a circuit of the filter bridge type constructed in rectangular section waveguide. The combined output is then conveyed to the aerial by an elliptical waveguide having dimensions of 12 in. by 6 in. The waveguide is made up of 99·5 per cent. aluminium in 12 ft. lengths. At the top of the television mast the waveguide is transformed into a 5 in. concentric feeder to take power to the four driving points of the aerial. The pole supporting the vertical helix aerial forms the outer of the concentric feeder.

The helical aerial is made of ½ in. diameter copper rod and comprises four bays mounted one above the other on the same vertical axis. Each bay has a linear height of five wavelengths and is fed at the centre, the helix being wound from the central point of the bay in opposing directions to cancel the vertical component of the radiation. In the four bays there is a total of 48 turns, each turn being about two wavelengths long. The aerial is mounted on the summit of the Crystal Palace tower, the top of the 6½ in. diameter pole supporting the aerial being 707 ft. above ground. The aerial has a power gain of 20 and, after allowing for losses in the feeder and waveguide system, the effective radiated power of the vision signal is of the order of 125 kW peak white in the horizontal plane. Provision is made for de-icing the aerial by electrical heating.

Marketing

NEW STYLE TRADE MISSION

The Canadians now in this country as members of the largest trade mission ever sent to Britain by any country are here to buy British goods. They are a purchasing mission—this was emphasised repeatedly at a Press conference held by the Canadian High Commissioner, Mr. Drew. Fifty-seven people have come for almost one month to see what our industry can supply competitively both with their own and with that of the United States. Their leader, Mr. Gordon Churchill, who is the Canadian Minister of Trade and Commerce, made quite clear to the unusually large Press contingent who attended that the mission was particularly concerned with the search for new sources of supply for items now bought in the United States. To Canada this is a very important matter for, unless a substantial switch from United States to United Kingdom sources is secured, a serious trade deficit will become worse and will threaten the country's economic and political independence.

Mr. Churchill has brought over leading industrialists picked because (*a*) they are in sympathy with their Prime Minister's aims, (*b*) they are men who can place orders—their purchasing power was said to be " hundreds of millions of dollars "—and (*c*) they are pro-British. This does not mean that they will buy products which are not competitive, either in price or delivery, nor will they buy products which cannot be serviced at least as well as those purchased across the United States border. It is hoped by both sides that they will encourage the establishment of a good spares service on a basis which will inspire confidence in the long-term character of the manufacturer's interest.

The Canadian Government point out that 4,167 million dols. worth of goods was imported from the United States in 1956, and that the trade deficit amounted to more than 1,500 million dols. Imports from Britain totalled only 485 million dols., which was over 300 million dols. less than Canada exported to Britain. This situation limits Canadian exports to us; it also holds back British investment in Canadian industry. To a large extent the trade deficit with the United States has been obscured by the large amount of American investment in Canada. As Mr. Diefenbaker pointed out soon after becoming Prime Minister, " the heavy influx of United States investment has resulted in some 60 per cent. of our main manufacturing industries, and a large proportion of our mine and oil production, being owned and controlled by United States interests." His Government wish to reverse this trend and the mission are here to help. The preaching will be by example: members will place orders or initiate inquiries and by doing so will demonstrate in the only manner likely to be convincing to their compatriots that British goods are competitive and can be bought with confidence. A 15 per cent. switch from United States to United Kingdom sources represents 620 million dols. worth of goods, and most of the interest is in plant and machinery. The mission believe this possible; it means more than doubling our total exports to Canada and probably trebling our exports of plant and machinery. A short guide to the opportunities that exist for engineering firms will shortly be published in ENGINEERING. An additional £200 million of exports to Canada could transform our own trade position.

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American Market Place

The current efforts being made by the Governments of Britain and Canada and by the Dollar Exports Council lends special interest to the forthcoming second annual United States World Trade Fair to be held next May in New York. A publicity leaflet recently received claims that the Coliseum where it is to be held is " the greatest market place in the Western Hemisphere."

The first fair held last April attracted over 700,000 visitors, including nearly 128,000 buyers from all parts of the world. Forty-three nations participated officially and 3,000 exhibitors displayed products and raw materials from 60 countries. The " ardent support and co-operation " of the Governments of the United States, the New York State and New York City was received. The organisers estimate that over 1,000 million dols. in business will result. The Mayor of New York, Mr. Robert F. Wagner, explains that this year's fair is being held and the event being made an annual one " because the Fair's enormous success exceeded all expectations last spring." Mr. Averell Harriman, Governor of the State of New York, included in his message that the fair had demonstrated " its great abilities to attract the kind of wide-spread attention, and to stimulate the type of interest among businessmen, which are vital in helping restore to its rightful place the concept of expanding world trade as an essential ingredient in establishing world peace and prosperity." Few better opportunities are likely to present themselves to show our wares to our North American friends.

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Britain and Europe

One of the more surprising things about the proposed free trade area and the common market is the manner in which British industry has acted in advance on the assumption that it was a " dead cert." Many firms known to us have recently concluded agreements in manufacturing licences, set up sales offices on the Continent, invested in German, French or Italian firms or in other ways demonstrated both their expectation of a move in that direction and their intention to be in at the start. We find this highly encouraging, since this kind of approach is likely to bring about industrial integration more quickly, less painfully and much more effectively than any purely political action.

There has been a great deal published on the subject, but so far very little which is the result of serious study. The *Economist* Intelligence Unit has for some months been engaged in the preparation of " a handbook " on the subject, assessing the possible effects on British manufacturing industry of a free trade area in western Europe. The publication date for the handbook is to be December 11, and the price will be 15*s*.

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Sales Managers in Conference

Europe was the central theme of the chairman's address at the annual general meeting of the Incorporated Sales Manager's Association. Following his election to the chair, Mr. Arnold Lucas, a director of Smith and Nephew Limited, referred to the conference on European Free Trade held at the Royal Festival Hall at the end of October. He said that his members' reactions during that conference made it plain " that the sales managers of British industry have their eyes open to what is happening in Europe—that they have their ears and their minds open too. They recognise the challenge."

Mr. Lucas attributed the success of the conference on free trade to its being an occasion not for propaganda for or against but for " an honest exchange of ideas on what is likely to happen and what we should do about it." He talked of coming changes in the pattern of European industry and trade and said that the response from " hundreds of top executives from outside our membership " convinced him that much more of this should take place. The task of the sales manager would not be changed but made bigger—and his department's functions as the eyes and ears of his firm would become more vital. Mr. Lucas believed that the movement towards free trade in western Europe would accelerate the rate of change, and also probably the resistance to change within manufacturing units. When the sales manager " looks not outwards but inwards to his products, and to those who manufacture them, he sees forces which, by their very nature, resist change." To overcome this resistance, to explain the need for change—in product policy in particular—the sales manager has a job of selling to do on the factory floor.

Mr. Lucas spoke wisely. The promotion of change is the sales manager's business. But it is not his alone: the research worker has his part to play in initiating change, and the market research department—which should never be the responsibility of the sales manager—a task of methodical collection and interpretation of market facts and opinions.

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The Middle East Re-Visited

Most engineering firms to whom the subject of Middle East markets is mentioned have one stock comment: " stone dead! " The Brush Group are an exception. With the blessing of the Board of Trade and a kind message from Mr. John Vaughan Morgan, Minister of State at the Board, their chairman, Mr. G. C. R. Eley, called a conference in Beirut at the end of last month of all his company's agents in 17 Middle East countries. This was attended by the group's factory managing directors, including Mr. Ian Morrow, managing director of the Group.

Brush are the largest British exporters of Diesel-electric equipment and have, as Mr. Vaughan Morgan pointed out, " an excellent record of exports to Middle East countries." Their aim is bluntly stated as " the launching of an all-out drive to beat international competition including that from Germany, Russia and America and ' sell British ' in one of the world's largest markets." The move is a bold one. Evidently the conference was carefully prepared and according to Mr. Eley is being hailed in the Arab world as " the first occasion in recent years that a British firm has signified its faith in the future of the Middle East." The conference banquet was attended by the President of the Lebanon and the British Ambassador. This, clearly, is the hard selling flamboyant enterprising way to knock out competition.

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Railway Maintenance

The lot of the steam locomotive builders has not been a happy one since the war but from within the industry the name of Beyer Peacock shines brightly. Their chairman, Mr. Harold Wilmot, is not only a salesman of ability but a business man vitally interested in change and betterment. He is the present chairman of the British Institute of Management and president of the Locomotive and Allied Manufacturers' Association. His group's performance since the war has been very satisfying, despite diminishing export markets for steam locomotives.

Their most recent step has been to conclude a licensing agreement with the Railway Maintenance Corporation of Pittsburgh, United States, for the manufacture in Britain of their complete range of track maintenance equipment. They have formed a new company, Beyer Peacock Railway Equipment Limited, to market these machines " throughout the Sterling area and in many other countries in the world." The equipment is said to permit substantial savings in maintenance costs to be made and to reduce shut-down periods. This should be of considerable benefit to railway running schedules.

Book Reviews

MOBILISING LABOUR: THE DEMOCRATIC WAY

Manpower: A Study of War-time Policy and Administration. By H. D. M. PARKER. *H.M. Stationery Office, York House, Kingsway, London, W.C.2*; and *Longmans, Green and Company, Limited, 6 and 7 Clifford-street, London, W.1.* (40*s.*)

Labour in the Munitions Industries. By P. INMAN. *H.M. Stationery Office, York House, Kingsway, London, W.C.2*; and *Longmans, Green and Company, Limited, 6 and 7 Clifford-street, London, W.1.* (35*s.*)

In the mood of defeatism with which the democracies faced the totalitarian régimes of the nineteen-thirties it was frequently stated that one of the advantages of dictatorship was its power to mobilise resources, including human resources, without regard to vested interests and without the delays of the committee system. At a time when the world is gaping in amazement at Russian achievement, it is a healthy corrective to read these two books and to be reminded of the part that the organisation and control of people played in securing victory twelve years ago. Britain, in fact, finally achieved a far higher degree of control over her economy than did Germany at any time, and with less interference from vested interests and corruption. This satisfactory result was not achieved, of course, without a substantial surrender of democratic rights; but parliamentary and Press criticism continued, trade unions flourished, and strikes, albeit illegal, took place without bloodshed. In the event, both the mobilisation of manpower for the Services and for industry, and the subsequent unwinding of the process for the return to a civilian economy, took place, not without argument, criticism and friction, but, nevertheless, surprisingly smoothly.

The credit for this success must go partly to those officials, chiefly of the Ministry of Labour, who were able to draw on the experiences of the first World War, when the realisation of what was required did not occur until nearly the end, and partly to Ernest Bevin, whose intellectual stature and working-class understanding ensured just that correct balance between compulsion and persuasion which was required to achieve the best results. Or so the author of the first of these two histories of the organisation of manpower thinks; although he is aware that there were many critics, often in the Service and supply ministries, who would have preferred a more ruthless approach, as well as economists in the Treasury who were fearful of Bevin's insistence on the maintenance of collective bargaining and opposition to wages control.

In spite of plans having been drawn up before the war, little was done, even after war was declared, to put them into operation, and unemployment continued throughout the period of the "phoney war," although some redeployment took place during the period. Perhaps even the Government of the time recognised that the problem was a political, and not an administrative, one and that any attempt to introduce strict controls while large sections of the population had no confidence in the direction of the war was impossible. With the formation of the Coalition Government, the situation was immediately changed and it is, therefore, all the more surprising to learn from Mr. Parker that it was Neville Chamberlain, as Lord President of the Council, who, in the discussions on the Emergency Powers Act, advocated full control over the persons and property of all citizens. Bevin's opposition to such drastic control was part of his general preference for trusting people to act rightly when their duty was made clear to them. At the same time, he never failed to act promptly once a Cabinet decision had been taken.

These two excellent histories illustrate the extraordinary difficulties of estimating manpower requirements months ahead and in the face of changing strategic needs. By 1942, a change had to be made from the system whereby the Ministry of Labour attempted to fulfil the estimated needs of the Services and ministries, to a system under which demand had to be adapted to supply. In the inevitable conflict that arose in this process of producing a manpower budget the outstanding part as mediator played by Sir John Anderson (now Lord Waverley), first as Lord President of the Council, in succession to Chamberlain, and afterwards as Chancellor of the Exchequer, is very clear. One of the early mistakes which might have proved serious was the failure to realise the shortage of scientists and engineers which a modern war would expose. In particular, the development of radar produced an acute shortage of wireless personnel of all types. The emergency measures taken to deal with the situation included the provision of State bursaries at universities and technical colleges, six-month full-time courses for Higher National Certificates, and engineering cadetships for the Services. These schemes were successful in producing substantial numbers of engineers and technicians both for the Services and for industry. The full-time "crash" courses for Higher National Certificates might well be worth reconsidering, in view of the present national position.

Together, the two books paint a fascinating picture on three levels: the committees in Whitehall where the plans and regulations were thrashed out, the regional and district offices of the Ministry of Labour and the supply ministries who had the unaccustomed tasks of allocating labour according to the directives they received; and the factories and dockyards into which so many men and women came for the first time in their lives. Compared with the first World War, the outstanding features were the spread of a more human approach to labour problems, as a result of the advance of psychological knowledge, and, in spite of much backwardness, the improvement in managerial skills and industrial relations.

It was Bevin's common humanity and understanding which enabled him to foresee the difficulties which the large-scale compulsory movement of labour, both men and women, would entail, and to insist on working and living conditions which should ensure, as far as possible, that morale and output were maintained over the long period the war was going to last. And, almost to the end, they were maintained.

Reading of the committees and the conflicts, the bargaining between ministries and between the trade unions and industrialists, one wonders whether, under a totalitarian system, it can be different. It seems more likely that, if the conflicts that are inevitable in any organisation are driven back into the administrative machine, the loss of efficiency may well be much greater than when they are allowed to work themselves out in full and frank discussion. It may be that the democratic system, by bringing to the surface, even in wartime, the existence of divergent interest groups, provides not only a more tolerable climate, but, ultimately, a more efficient system as well.

AERODYNAMICS FOR DESIGNERS

Aerodynamic Components of Aircraft at High Speeds. Edited by A. F. DONOVAN and H. R. LAWRENCE. Volume VII of *High Speed Aerodynamics and Jet Propulsion. Princeton University Press and Oxford University Press Amen House, Warwick-square, London, E.C.4.* (120*s.*)

The great increase in aerodynamic knowledge during the past decade was originally presented in numerous separate documents, but a compact source of the essential aerodynamics is needed by practising aeronautical engineers. The series to which this book belongs provides such a source.

For convenience, aerodynamics may be divided roughly into theory and experiment, each of which may be sub-divided into methods and results. Also, an aircraft can be viewed as a whole or as the sum of several components such as the wings, the fuselage (or body), the tailplanes and the engines. This Volume VII is concerned primarily with the presentation of theoretical results for the separate aircraft components. It includes details of some theoretical methods—this general topic has already been treated fully in Volume VI—and some comparisons with experimental results, but a comprehensive discussion of experimental methods and a review of the aerodynamics of the whole aircraft are to be given in the forthcoming Volume VIII.

There are seven chapters, dealing with different aspects of the subject and written by different authors distinguished for their own researches: isolated wings in steady flow are discussed by R. T. Jones and Doris Cohen; isolated bodies, by C. E. Brown; various lifting interference effects between wings, bodies, propellers and tailplanes, by C. Ferrari, aided in translation by R. H. Cramer; propellers, by C. B. Smith; diffusers and nozzles for jet engines, by J. C. Evvard; isolated wings in nonsteady flow, by I. E. Garrick; comparisons between theory and experiment for some isolated wings, by C. W. Frick. The complete tome, for such it is, runs to 850 pages, of which the chapters on wings in steady flow and interference effects each contribute about 250 pages, and the chapter on wings in nonsteady flow is nearly 150 pages long. There are several astonishing omissions from the index, which is by no means comprehensive, but to some extent the seriousness of this deficiency is lessened by the lists of cited references at the ends of the chapters. The book is most attractively produced.

The quality of the chapters is not uniform and accordingly they must be judged separately, but one comment applies to all: the information presented is not up-to-date. The reader cannot expect, of course, to find a truly up-to-the-minute account of such a rapidly expanding subject in a text-book, but here the inevitable time lag through publication has been aggravated because the authors were hampered in composition by security restrictions. Firstly, then, the substance and presentation of the chapters must be judged from the point of view of the unclassified information which existed at the time of writing, which may be guessed to be not later than 1953. Secondly, the developments which have taken place in the meantime must be considered.

From the first standpoint all but two of the chapters are very good. Indeed, the chapter on isolated wings in steady flow is a superb exposition, concise and beautifully composed. The treatment of isolated bodies, however, is inadequate. The chapter on lifting interference effects is a mine of information, but is verbose and not consistently systematic and lacks a

perspective appraisal. Supersonic propellers are discussed with straightforward clarity. In contrast to the chapter on interference, the chapter dealing with diffusers and nozzles is both an excellent introduction to and summary of the subject. The treatment of wings in nonsteady flow is also a very careful study and an extra effort is made to provide the maximum information for the reader by the addition of a bibliography after the cited references. The final chapter is a token discussion of some favourable comparisons between theory and experiment, and this is neatly written although it is evident that the author was straining at the security leash.

Security declassifications and unclassified advances since the book was written have important effects on the chapters on interference and experimental comparisons. In recent years the attitude to aerodynamic interference has shifted from a reluctant acceptance of the need to calculate its effects to an almost gleeful anticipation of the benefits that good design may bestow. This change originated in the discovery of the transonic area rule of interference drag at zero lift. No attempt is made in this volume to discuss interference drag, however, and therefore it may be hoped that a full description of the area rule and the consequent widespread developments will become available when Volume VIII is published.

This book, then, may be likened to a date-stamped but nevertheless much improved version of the curate's egg: it is very good in most parts. Despite its shortcomings it should become a standard work.

GEOMETRY OF GEARS

Grundzüge der Verzahnung. By A. K. THOMAS, V.D.I. *Carl Hanser-Verlag, München* 27, *Kolbergerstrasse* 22, *Germany*. (34 DM.)

Here is a major advance in the art of publishing technical books. It should be studied by anyone who is considering writing or publishing a book in which large numbers of diagrams are necessary to the understanding of the text. In effect, the book consists of two volumes, one of text and one of illustrations, bound in such a manner that on opening it each of them may be opened at the appropriate page, when the book is laid flat on a table, without any interference between the two. The Carl Hanser-Verlag is to be congratulated on producing such an admirable volume.

The book is concerned with the geometry of gears, and forms a companion volume to the author's successful book on the stressing of gears. It contains everything that the normal gear designer is likely to require, including seven figure tables, connected with the geometrical side of gear design, whether involute of cycloidal, applied to all common forms of gearing.

For completeness, short sections, which are not of the same standard as the rest, have been added on tooth loading and on obtaining the ratios and efficiencies of epicyclic gears. The diagrams are models of what diagrams should be, and it will be surprising if many of those who try to teach the theory of gears do not have slides made for themselves from quite a number of the 200 or so that form the second half of the book, together with the tables.

The author has been working in this country for some years, and as a result provides all the necessary data not only in terms of German practice, but also of British and American, and quotes the relevant standards. His references also cover books published in all three countries, but are by no means exhaustive. A curious gap in this book is that no reference is made to the geometrical problems involved in obtaining fluid film lubrication in worm gears; the classic work on this, which leads to a concave flanked worm tooth, is now being exploited commercially in Germany. (See Niemann, V.D.I.—Forschungsheft 412). Only long use of a book such as this can reveal its true worth; but it may well prove to be worthy of a place alongside "Buckingham."

On the Shelf

By Frank H. Smith

I do not know what the annual birth rate of libraries is but I am sure that one, at least, of the problems encountered is what to choose as the basis of the collection. What is new in the subjects to be covered? How much will it cost? How much should one allow? Many of these questions are conveniently answered by H. K. Lewis and Company, Limited's new catalogue of books on civil and mechanical engineering, obtainable gratis from P.O. Box 66, 136 Gower-street, London, W.C.1. This list is subject-headed into civil engineering, mechanical engineering, aeronautical engineering and industrial organisation and management. These main headings are, in turn, split into subsidiary headings making it all very simple. The pagination, date of appearance of the work, and the price, are also given.

An interesting new publication from Hungary is *Periodica Polytechnica* from Budapest. This is a quarterly covering engineering (apparently with the accent on structures), electrical engineering (including applied physics) and chemical engineering. It would seem that papers will be published in English and/or German, and inquiries should be addressed to Periodica Polytechnica, Postafiok 440, Budapest 62. The subscription is 4 dols. a year but the Budapest Polytechnical University will apparently welcome exchange arrangements for equivalent English journals.

At the recent one-day conference organised by Aslib in connection with the provision of libraries for schools of technology, much was talked about Circulars 322 and 323 of the Ministry of Education. From the first of these, *Libraries in Technical Colleges*, I quote paragraph 6 under the heading "Staff." It deals with the appointment of a qualified librarian and says: "He should be acceptable as a colleague by members of the teaching staff, with whom he must maintain close and constant contact." The first half of that sentence is such a piece of ignorant pompous snobbery that I am left speechless.

A journal put out by the Aircraft Industries Association of America has discovered a new statistic. When the new jet aircraft start circumnavigating the world, travellers will be concerned not only with "zone time" but also with "stomach time." For instance, if a passenger flying from San Francisco eastwards arrives in Paris at noon local time, his stomach would only be at 3.10 in the morning. And who wants lunch half-way through the night?

The Engineering Institute of Canada has disinterred an old publication; the *Transactions*, which ceased in 1932, start again with No. 1 of September. They will print papers which would be too long, or have too narrow an interest, for the *Journal* and, in addition, they will form an outlet for material which the E.I.C. is now receiving from the National Research Council. The format is most unpretentious and the first number, at any rate, contains no advertisement. Just a plain cover and 43 pages of meaty content.

LIBRARIES IN TECHNICAL COLLEGES

By Dr. W. A. J. Chapman, M.SC.(ENG.), M.I.MECH.E., M.I.P.E.

The need for good library facilities in technical education has been brought out in the White Paper on Technical Education, and further emphasised in a Ministry of Education circular (No. 322) on standards of library service in technical colleges. In the light of these recommendations, Aslib recently held in London a one-day Conference on Library Services in Technical Colleges, at which some 350 representatives from industry, the technical colleges, education authorities and advisory councils, and various ministries met together to discuss the question.

In opening the conference, Sir Edward Boyle, Parliamentary Secretary to the Ministry of Education, stressed the need for co-operation between industry, and those who formulated library policy. Following on the Government's plans for technical education, the number of sandwich courses has risen from 100 to 200, and 49 of such courses have been recognised for the Hives award. Technical colleges to-day need better libraries, more intensive use of those available and the maximum co-operation with industry.

The liberal element in technical education was discussed by the Earl of Verulam, chairman of Enfield Rolling Mills Limited. His contention was that the use of knowledge can be increased if the user was versed in the tradition of thought which made philosophy and science possible. For this purpose the cultural atmosphere of the colleges, and the method by which subjects are taught, may be as important as the choice of subjects. The division into watertight compartments can, he suggested, only be avoided by good teachers and good libraries. Increased access to books during higher examinations could help the student to cope with the conditions he would meet in his subsequent profession.

One of the pioneers in promoting library services for technical colleges, Mr. S. T. Broad, chief education officer, Hertfordshire County Council, described the Hertfordshire Technical Library Service. This service was started to disseminate information, and to create receptiveness for new ideas, among educationists, scientists and laymen. The Hertfordshire service operates through the County Library, three technical colleges, and eight colleges of further education, with close liaison with the libraries existing in firms in the area. Industrial contacts already exist through the colleges and their students, and the service envisages an increased use of books through systematic instruction in the colleges. Contact will be maintained with firms through the staff and students, and a card information service will provide a continuous flow of information.

Dr. J. Topping, principal of Acton Technical College, spoke on the library as an educational instrument. He considered that libraries should be integrated into teaching in the same way as laboratories and workshops. Teachers should make increased use of the library so that the recommendation of books to students should be backed by intimate knowledge, and work given to students should demand the use of the library, so that they may appreciate the spate of ideas and developments, and keep up to date.

Co-operation with local industry was considered by Mr. P. P. Love, director of research and development, the Glacier Metal Company Limited. Increased use could be made of works' libraries, he thought, through interchange schemes for periodicals, and co-operative lending schemes for books. Although relatively few inquiries are made by firms from library and information services, this is probably because they are often unaware of the merit of existing literature. All literature, he suggests, should be given a merit rating, by independent referees at national level.

Design

REMOVING THE TELEPHONE OPERATOR —GRACEFULLY

The reductions in telephone charges expected next January result from a new system of grouping exchanges. Group Routing and Charging Equipment, devised by Post Office engineers, makes the system possible. The equipment, known as GRACE, interprets numbers dialled, routes the calls to the correct exchanges, and dials the required number. All exchanges in a group will have the same charges. The system paves the way for an automatic trunk service.

GRACE does automatically what a trunk operator now does manually. It notes the number dialled by a caller and decides on the correct route that the call shall take. It also decides on the correct charge rate. The equipment then guides the call along the route to the required exchange and, when the called subscriber answers, it enters the charge on the caller's account.

The equipment has three main parts—call chargers, registers, and translators. Various numbers of these parts are used in any one installation, depending on the number of calls to be dealt with. When a caller wishes to make an automatic trunk call he dials the national number of the person to whom he wishes to speak. The first digit of all national numbers is "0." Receipt of this digit by the exchange equipment causes the call to be connected to a call charger.

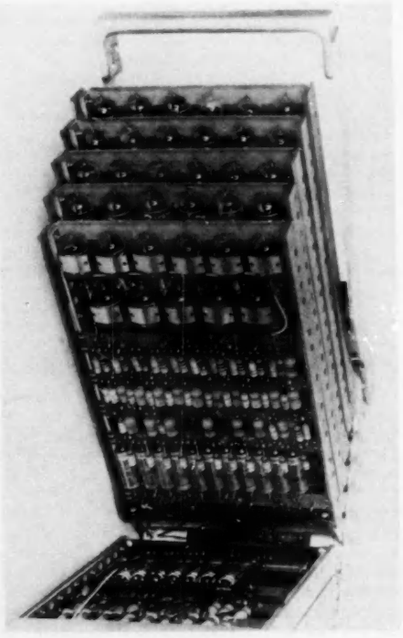
The call charger than associates itself with an available register. This serves as a memory and the remaining digits are entered into it. The first one, two, or three digits received by the register identify the distant group being called. It is the function of the translator to inspect these digits and to deduce from them the route and charge for the call. The translator can be considered as the brain of the system. It has a permanent memory with details of routes and charge rates for calls from the originating exchange to all other groups in the country. Having decided the route and charge, the translator sends this information back to the register.

The information is sent back as a series of digits. They are passed back one at a time as required. The register uses each digit supplied by the translator to further the setting up of the call and then makes a fresh demand for another digit indicating to the translator the one that is required. This removes the need for storage for the routing digits in the register. The register takes longer to use a digit than the translator takes to supply it. One translator can thus serve several registers.

The first digit to the register selects the appropriate charging rate in the call charger. Subsequent digits—they may be from 1 to 5 in number—are used by the register to operate switches in the originating and distance exchanges to complete the connection. When the connection is completed the register is released and made available for use with other call chargers in setting up further calls. The call charger remains connected throughout the call and, when the called subscriber answers, levies the charge by operating the caller's exchange meter at time intervals depending on the distance between the calling and called subscriber's charging groups.

The equipment has been developed in two different forms. One uses conventional electro-mechanical components—mainly uni-selectors and relays—and the other uses electronic techniques. The electronic version will be used in the first installation at Bristol. It is based on the use of cold cathode tubes. The Post Office have been experimenting with these tubes in telephone equipment for several years and experience has shown that very reliable service can be obtained. The voltage-transfer method of using the tubes has been adopted. With this method the output potential from one tube is sufficient to strike another tube, the potential being controlled by rectifier gates. Rectifier gating permits combinations of tubes to control the striking of another tube without mutual interference. Miniature selenium rectifiers are used to form the gates.

Digits are received by the registers in the form of dial pulses—a train of pulses for each digit. The pulses are counted on the incoming counter, which is a chain of cold cathode tubes. When a pulse chain ceases, the number of pulses counted is stored on five tubes in "2 out of 5" code by striking the appropriate two tubes. The incoming counter is then reset ready to count the next digit, and a second counting chain is stepped to keep check of the number of digits received. Up to nine digits may be received and each is stored on a separate group of five tubes, requiring 45 tubes for digit storage. Digits to be transmitted by the register are received from the translator and stored temporarily on the counting chain tubes of the outgoing counter. The register then generates pulses—like those generated by a dial—and as each pulse is transmitted it is counted by the outgoing counter until the correct number has been transmitted. The register then receives the next digit to be transmitted from the translator and as soon as the "inter train pause" switching period has expired, this digit is transmitted.



Equipment mounted on "leaves" hinged together at the rear to form a "book." Cold cathode tubes are mounted at the front of the leaves.

The electronic translator can deal with a register in a few milliseconds. The high speed of operation permits the translator to be connected to a register at regular intervals, whether the register requires the translator or not. The translator acts as a common control. Each time it is connected to a register it can decide what action, if any, is required. This common control arrangement permits a simple design of register, for the register is merely a slave acting on instructions from the translator. Registers are connected in sequence and up to 40 may be controlled by one translator, each register being connected once every two-thirds of a second.

Because a translator is common to as many as 40 registers a faulty register could seriously disrupt service to subscribers. It is arranged therefore that any mis-operation is detected by check circuits which cause a standby translator to take over service automatically.

The equipment is mounted on standard telephone racks. For the electronic equipment these are box section and divided into cubicles catering for 20 registers per rack or three translators per rack. Equipment within a cubicle is mounted on "leaves" that are hinged together at the rear to form a "book." The construction can be seen in the accompanying illustration, reproduced by courtesy of H.M. Postmaster-General. Cold cathode tubes are mounted at the front of the leaves so that their glow can be seen through the red-tinted front cover.

The initial installation at Bristol will comprise 66 registers and three translators. Two of the translators will be in service normally, the third acting as a standby for either of the other two. The equipment can handle about 6,000 calls per hour, and can establish connection to the called subscriber within seconds of the completion of dialling. The system has been devised by Post Office engineers and the equipment for the initial installation has been designed and developed in co-operation with the General Electric Company, Limited, Kingsway, London, W.C.2.

STAGNATION IN BICYCLE DESIGN?

With a machine which has been in existence as long as the bicycle, it is tempting to conclude that finality in design has been reached. Innumerable alternative designs have been tried and have disappeared and, in recent years, investigations into the possibility of using light alloys more extensively have come up against the fact that the bicycle as at present produced represents a remarkably efficient use of materials. But a jolt has been administered by the recent report on tests of pedal cycles and motor-assisted bicycles made by the Road Research Laboratory of the Department of Scientific and Industrial Research, following the high casualty rates found with the second class of machine. The report shows a surprisingly low level of efficiency for cycle brakes, especially in wet weather, when stopping distances may increase from 1½ to 4 times. Braking efficiencies of 0·36 to 0·56 in dry conditions dropped to 0·14 to 0·31 in the wet. Rim brakes deteriorated badly in the wet, but some drum brakes also proved vulnerable, and seemed to need better sealing against water.

In the face of these results it is surely verging on frivolity for a spokesman of the cycle and motor-cycle manufacturers' association to say: "Cycle brakes may be affected by rain and wet. This weighty conclusion has been common knowledge among cyclists for 30 years and more. The good cyclist makes a practice in wet conditions of applying his brakes lightly and at frequent intervals, in order to dry out his brakes." Presumably the others become casualties.

It was found that brake blocks softer than those in current use gave much better results, but tended to compress and harden in use. Cutting grooves to increase specific pressure did not help. Apparently there is not time to break through the water film, and the problem is akin to that of the tyre of a fast-moving vehicle on a wet road. However, brake blocks twice as long as those now used, in a cork-rubber material, produced a 40 per cent. improvement in wet-weather braking, and unplated rims were 20 per cent. better than chromium-plated rims.

Bicycle dynamo lighting sets were also criticised for low beam intensity, poor beam distribution, and poor voltage control. The report suggests little cause for complacency on the part of those responsible for bicycle design.

PHYSICS IN REACTOR DESIGN

A Pictorial Summary of Elementary Nuclear Concepts

By G. W. K. Ford, M.B.E., M.A., A.M.I.MECH.E., A.M.I.E.E.

Reactor engineering has in a short time become the concern of many engineers with little prior knowledge of nuclear science. It is with this in mind that we are publishing a treatment of elementary reactor physics designed to be quickly and easily assimilable. The article should also serve as a convenient introduction for those coming fresh to nuclear work. In adopting a pictorial approach, the author has succeeded in condensing all the major basic concepts into a small space, but recognises that such a treatment calls for study rather than a single reading. The article is to be published in several parts, the first of which appears below. Mr. Ford is Research Manager of the experimental criticality group at the United Kingdom Atomic Energy Authority's establishment at Dounreay in the North of Scotland.

OVERALL TOPOGRAPHY

Following a period of development by physicists and mathematicians, the relevant parts of thermodynamics, electromagnetic and, later, electronic theory, aerodynamics and many other sciences have become the working subjects of the engineer. In a similar manner much of nuclear reactor theory is now passing from the scientific specialists to the nuclear engineers; though, as in other fields of engineering technology, the physicists and mathematicians will doubtless always have much new ground to break and will continue to develop new theories and methods while the practising engineer utilises and applies the results of their earlier work.

In the science of heat engines many phenomena can be seen by the eye and felt by the hand, and the combination of acute direct observation and well-developed "common-sense" can and did lead to the development of useful machines. A complete thermodynamic analysis followed many years later; and further improvements to the performance of machines were a consequence. In aerodynamics, a subject which grew up almost two hundred years after the first useful heat engines, a better developed scientific method was available as a background to accompany the development of practical machines, so that the quantitative theories and the machines developed simultaneously; and also much more rapidly. In electrical engineering and in the later development of vacuum-tube electronics, however, much laboratory work had to precede the practical applications because the phenomena of interest were not so directly observable by the human senses as those connected with the development of mechanical forces from fluids such as steam and air. To make use of electromagnetic phenomena in practical machines it was necessary first to devise instruments to detect and measure the comparatively unfamiliar electromagnetic effects and then to develop quantitative theories to enable the effects to be calculated and predicted: the application of direct observation and "common sense" was not so straightforward as with gas-forces.

The existence of neutrons and the occurrence of nuclear fission could never have been detected without the aid of techniques even more indirect than those necessary to detect electric currents, and, as is well known, within the field of nuclear physics itself these two particular manifestations were not discovered until the subject was several decades old. It is not intended to make any reference in this article to the means of detecting and measuring the presence of nuclear particles and their effects, but it will be realised that until these had been devised, and unifying theories developed, it would have been quite impossible even to have imagined the possibility of a nuclear chain reaction in other than metaphysical terms.

It thus comes about that the nuclear reactor was born in the laboratory as a result of much experience in the experimental observation of the properties of nuclear particles, coupled with considerable insight and imagination to point the way to the devising of processes in which the observed phenomena could be assembled together to produce a self-sustaining nuclear chain reaction. It is hardly surprising therefore that the text-book literature of this subject has taken the form of a combination between the logical presentation of the subject from first physical principles and an account of the general historical thread of its development in the laboratories of nuclear physicists and in the offices of theoreticians. Thus the standard text-books require the reader to digest a considerable amount of nuclear physics before it is deemed possible to present to him the essential features of the nuclear chain reactor. Because the important phenomena cannot possibly be experienced by the senses and must necessarily be observed by indirect means, and because they are in themselves complicated, this state of affairs cannot altogether be avoided. It does seem possible, however, to go some way towards the simplification of the presentation of this material so as to provide a comprehensive picture of the subject which will act as a simplified, but still quantitative, "small-scale sketch-map," the purpose of which is to serve as a guide to the more detailed and "larger scale local" sections of the "map," in which particular aspects of the theory may be studied to a greater degree of refinement, thus avoiding the study of fine "topographical" detail before the student has acquired a general picture of the shape of the "country" as a whole.

This article represents an attempt to attain these objectives. First are presented the basic nuclear phenomena important to reactor theory, after which follows a "skeleton" development of the theory of nuclear reactors. Where possible, refinements of theory aimed at securing greater accuracy in particular features have been eliminated so as not to fog the main pattern of the theory viewed as a whole. It is hoped that this article may thus come to serve as a guide to the text-book and other more specialised literature in which the subject is treated in much greater detail and degree of refinement.

Nuclear and atomic theory require for their full understanding, as far as they have gone to the present day, a considerable background knowledge of the subjects of modern physics such as quantum theory and wave mechanics, entailing as they do sophisticated mathematics beyond the range of most practising engineers. Nevertheless it is a fortunate occurrence that the theory of nuclear reactors has been worked out by the use of fairly crude mathematical models which assume hard-particle properties for the interacting nuclear particles, and therefore analyse the interplay of phenomena in terms of "billiard ball mechanics."

The strange properties of nuclei which the physicist would analyse in detail by means of the wave mechanical and other advanced models can be thought of throughout the whole theoretical treatment of practical reactor theory as merely creating the effect of billiard balls with sizes varying as the game proceeds, depending upon the relative speeds of the billiard balls upon the "table." The game is played in three dimensions, with an infinite number of balls of several different types, all of which change their apparent size and properties as "seen" by the neutrons, in accordance with their relative speeds. The mathematical analysis of this fantastic game can present most complicated problems to the mathematician which may cause him to use some of the best weapons in his armoury for their analysis. However, a great deal, of considerable practical utility, has been, and can still be done with relatively simple mathematics which do not go beyond the normal equipment of the practising engineer, and do not require him to extend his conceptual thinking beyond a modified form of the kinetic theory of gases. It is with these aspects that this article is concerned.

No originality is claimed for any of the subject-matter discussed, but it is hoped that the manner in which the material is presented will help to clarify some features of the subject which are sometimes not easy to grasp from the more detailed and comprehensive standard literature. A list of some of the standard text-books will be given, and the present author would like to acknowledge his indebtedness to the authors of these volumes, upon which most of the material presented here is based.

(A) BASIC NUCLEAR PHYSICAL CONCEPTS

(1) Nuclei, Stability and Sizes

Representation of Crystal Lattice (*Fig.* 1).—The diagram of Fig. 1 purports to show a corner of the crystal lattice of a crystallite of a solid substance. No one has ever seen an atom, let alone its internal structure, so that this is but a crude model of the unknown reality. Neither atoms nor nuclei really behave as if they had a clear-cut exterior surface, and modern theory represents an atom as consisting of a tiny nucleus surrounded by a diffuse cloud of electricity, the boundaries of which are not clearly defined and which may not even be spherical. However, for the present purpose it is convenient to imagine an atom as a minute sphere of diffuse electric charge about 10^{-8} cm. in diameter. In a solid it would be spaced from its nearest neighbours by distances about the same as its diameter. At its centre lies the exceedingly small, but enormously dense nucleus resembling a blackberry.

The nucleus is some 10,000 times smaller than the atom itself, that is about 10^{-12} cm. in diameter. If a nucleus were represented by a $\frac{1}{4}$ in. bearing ball its nearest neighbour nucleus would be over 100 yards away. The nuclear material is unimaginably concentrated, and a simple calculation shows that its density is some 100,000,000 tons per cub. cm. This is really just another way of emphasising that, if we neglect the diffuse cloud of electrons, which only makes up about one part in 3,000 of the weight of an atom, "solid" matter consists mainly of space with a few tiny points, the nuclei, which give the material its weight. For all their relative sparseness, however, there are astronomical numbers of them in any visible quantity of material: about 10^{23} in a cub. cm. If one fires a projectile in the form of a nucleus or part of a nucleus into a solid material one would expect the diffuse electron cloud not to affect it much because of the projectile's great mass. But it would travel a long way before striking a nucleus because the nuclei present a target area of order only 10^{-12} cm. by 10^{-12} cm., or 10^{-24} sq. cm. This is the basic unit of nuclear target area, or cross-section, called the "barn," and the average distance travelled by a projectile before making a collision is called the mean free path. The symbols σ and λ respectively are used to represent their values in mathematical working.

Stable and Radioactive Nuclei (*Fig.* 2).—There are about 100 different possible chemical elements; in fact 102 have now been isolated. Of these some 90 occur in nature, and the remaining 12, all short-lived in comparison with the age of the earth, have been produced by artificial means. The elements differ because the atomic nucleus in each case has a different constitution. The nucleus may be thought of as consisting of a

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ball or sphere of protons and neutrons packed in closely together as in Fig. 7, where the neutrons are black and the protons white. In the lightest atoms the nucleus is stable if the number of protons and neutrons in the nucleus are equal, but as the atomic number Z (the number of protons) increases so the number of neutrons increases more rapidly. In general, therefore, a nucleus contains more neutrons than protons. The number of unit-negative-charge electrons contained in the atom's outer structure directly governs the atom's chemical behaviour: an electrically neutral atom has the same number of electrons in the outer structure as it has protons in its nucleus. A nucleus containing a given number of protons can be at least temporarily stable provided it contains a number of neutrons lying approximately between the lines P and Q in Fig. 2. If when newly born, as a result of a nuclear reaction (for example fission), the nucleus does not lie roughly along the line R it will be radioactive and will spontaneously change its neutron-proton composition so that it eventually lies within the stable region close to this line. Such a change could take place in one of the following ways, depending upon the initial neutron-proton ratio of the newly-formed nucleus: (*a*) it could emit a neutron, as in the case of delayed neutron emission by certain fission products; in this case it remains the nucleus of the same chemical element, but becomes a different isotope of that element, since Z, the number of protons, remains unchanged; (*b*) it could emit a β^- particle (an electron) as a result of the spontaneous conversion of a neutron within the nucleus into a proton (plus the β^- particle), so that Z *increases* by one unit of charge and the original nucleus becomes transmuted into that of another chemical element; (*c*) it could emit a β^+ particle (a positron or positive electron), in which case a proton within the nucleus would have been converted into a neutron and Z would *decrease* by one unit of charge so that the original nucleus is again transmuted to that of another element; (*d*) the nucleus could capture an orbital electron and so change a proton into a neutron with the same result as in (*c*); or (*e*) the nucleus could emit an α particle (two neutrons plus two protons in the form of a helium nucleus) so *reducing* Z by *two* units of charge and the neutron number N by two units also. All these five processes are examples of radioactive decay, and they may also be accompanied by the emission of high-frequency electromagnetic radiation in the form of γ-rays or X-rays, and in certain cases also by neutrino emission.

If the newly-born nucleus happens to possess the correct neutron-proton ratio for stability (that is it lies roughly along the line R) it may still be radioactive because it contains an excess of energy which will in due course be emitted as γ radiation: but in this case the nucleus retains the same neutron-proton ratio and therefore is not transmuted into that of another chemical element. The different atoms corresponding to nuclei which possess a fixed number of protons, Z, and differing numbers of neutrons, N, which latter value must fall somewhere between the approximate limits set by lines P and Q, are called isotopes of the particular element, the chemical properties of which are determined by Z. Those on or close to the neutron-proton stability line R and which are not radioactive are called stable isotopes; the remainder, which are all radioactive, are termed unstable or radioactive isotopes. The chemical properties of the isotopes of a given element (Z-values) are almost indistinguishable whether stable or radioactive. Corresponding to the 100 chemical elements are nearly 300 stable isotopes and around 1,000 radioactive isotopes. Although of great importance in the practical applications of atomic energy and in the subject of nuclear physics, radioactivity as such does not need to be considered further in this article for the purpose of studying the physics of reactors and will only be mentioned again in connection with the production of delayed neutrons by fission products.

Size of Nuclei (*Fig.* 3).—There are numerous methods by which the sizes of the nuclei may be estimated, most of them depending upon the scattering of nuclear projectiles of one sort or another. The main result to notice is that the nuclear volume is proportional to the number of nucleons (neutrons plus protons) within the nucleus, so that the radius is proportional to the cube root of the number of nucleons in the nucleus, that is to the cube root of the mass number A. The mass or atomic weight of the nucleus is almost directly proportional to the mass number A, since neutrons and protons have almost the same mass. The nuclear structure can therefore be imagined as a spherical assemblage of nucleons which are closely packed together rather like the pips in a blackberry or a fish-bowl of billiard balls. (White balls represent positively charged protons; black balls electrically neutral neutrons.) In reality the structure is thought not to be static, the nucleons interchanging positions in times of the order 10^{-20} sec.

(2) Nuclear Reactions and Cross-Sections

Neutron-Nucleus interactions (*Fig.* 4).—Neutrons, protons, gamma-rays and other nuclear projectiles can cause changes to target nuclei, but for elementary reactor physics only the neutron-nucleus interactions need be considered. Neutrons can easily penetrate nuclei and interact with them because they carry no electric charge; other particles contain protons and are therefore strongly electrostatically repelled by nuclei. Elastic scattering is important in neutron diffusion theory, and may be thought of as inter-billiard-ball collisions in which both mechanical energy and momentum are conserved. In inelastic scattering, a phenomenon taking place at high neutron energies, mechanical energy is not conserved and the colliding neutron loses more energy than in an elastic collision and is therefore slowed-down more. The "lost" mechanical energy usually re-appears as a gamma ray emitted later by the target nucleus. The three non-fission absorption processes shown in Fig. 4 all result in the loss of a neutron so far as the propagating of a neutron chain reaction is concerned, and are lumped together for reactor calculation purposes, the dominant processes for reactor energy neutrons being the (n, γ) reactions.

Cross-sections at High Energies (*Fig.* 5).—The likelihood that a neutron-nucleus interaction will take place depends, among other things, upon the speed of the projectile neutron. Because of its more direct significance in nuclear processes, however, it is more usual to deal in terms of the incident neutron's kinetic energy E, equal to $\frac{1}{2} m v^2$, where m is the neutron mass ($1{\cdot}66 \times 10^{-24}$ gram), and v its velocity. This is usually measured in electron-volts (eV). One electron-volt is the kinetic energy acquired by an electron (unit negative charge $= 1{\cdot}6 \times 10^{-19}$ coulombs, mass $= 9{\cdot}11 \times 10^{-28}$ gram) when accelerated through a potential difference of one volt, in which event the work done on the electron is equivalent to 1 (volt) $\times$ $1{\cdot}6 \times 10^{-19}$ (coulombs) $= 1{\cdot}6 \times 10^{-19}$ joules $= 1{\cdot}6 \times 10^{-12}$ ergs $= \frac{1}{2} m v^2$. Neutron energies of interest in reactor work range from about one-hundredth (0·01) eV to about ten million (10,000,000) eV (or 10 MeV). At the high energies all cross-sections are small and the dominant effects are scattering phenomena. Fig. 4 shows how, for 10 MeV neutrons, the apparent target area presented by the nucleus for all phenomena added together appears to be about twice the "real" disc area of the nucleus, that is $2 \pi R^2$ where R is the nuclear radius.

Cross-sections of Elements Important in Reactor Technology (*Fig.* 6).—When the projectile neutrons have low energies (below, say, 1,000 eV) the apparent target areas of nuclei vary enormously, first as between the different elements, and secondly, often with very small changes in projectile kinetic energy, or relative speed as between projectile and target; target nuclei are usually considered to be "at rest" relative to the projectile neutron. Fig. 6 shows the behaviour of the nuclei of several elements of importance in nuclear technology. Notice particularly that at energies of between 0·01 and 0·1 eV the total cross-sections may be several hundred times the high energy (keV, MeV) values. Note also that over certain small ranges of energy the cross-section increases to very large values: almost to 10,000 barns in some of the peaks shown. These peaks are called resonances and, for nuclei of medium or high atomic weight (or high Z), are generally confined to incident neutron energies of less than 1,000 eV. The total resonance cross-section will contain both absorption (e.g. (n, γ), (n, f), etc.) and scattering (n, n) components, and one or other may dominate depending upon the properties of the particular nucleus. In the examples shown (U235, U238 and Cd) the absorption cross-section is by far the most important process at resonance, but for other nuclei (e.g., Al or Bi) the reverse is the case, and scattering is the dominant process. Between the resonances the total cross-section is predominantly that of scattering, and lies, for all elements, between about 1 and 10 barns, which is not very different from the MeV values (about twice, that is $\sigma_s \simeq 4\pi R^2$ compared with $2\pi R^2$).

The absorption processes vary considerably between the various elements. The chain-dotted curve C shows the total cross-section for carbon. This is almost entirely a scattering cross-section: even at the low energies (0·025 eV) the absorption cross-section is only a few thousandths of a barn. Boron (B^{10}) on the other hand, which has much the same total cross-section as that of carbon at high energies, where the dominant process is scattering, at low incident neutron energies develops a very large (n, α) absorption cross-section that completely dwarfs the scattering cross-section, which remains at a few barns. Boron is said to be a $1/v$ absorber because its capture cross-section increases inversely as the neutron velocity (that is, as $\sqrt{E}$) increases. Whereas boron has no sharply defined absorption resonances at low neutron energies, cadmium (Cd) has; again its scattering cross-section remains almost constant at about 7 barns over the whole range except at the resonances. In the case of the abundant isotope of uranium, U238, it is seen that the total cross-section has a general level of about 10 barns. Most of this is scattering, predominantly elastic at low energies, inelastic at high energies. Superimposed upon this are the very large absorption resonances which occur between about 6 eV and 200 eV. Notice that at energies greater than about 1MeV there is a small (up to 0·5 barn) chance of fission occurring instead of (mostly inelastic) scattering (several barns). Finally, it is of importance to examine the fission cross-section of U235, the uranium isotope present to the extent of about 1 part in 140 in the natural metal. Only about one barn in the MeV region, it rises to several hundred barns in the 0·01 to 0·1 eV region and shows resonances in the 1 to 100 eV range. The scattering cross-section of U235 is not shown but generally resembles that of U238. The non-fission capture of neutrons by U235 has also not been shown, but is dealt with in the sections referring to Figs. 10 and 11 below.

(3) Nuclear Fission

The Fission Phenomenon (*Fig.* 7).—Several of the heavy-element nuclei can be fissioned by neutrons, a few of which are of importance as reactor fuels. The isotopes U235, Pu239 and U233 may be fissioned by neutrons of all energies (especially easily by thermal neutrons), but U238 can be fissioned by fast neutrons only. Fig. 7 illustrates the fission of U235. The likelihood of this event occurring has been dealt with in the section associated with Fig. 6, which includes the cross-section for neutron-induced fission of U235. The incident neutron is captured by the nucleus, which becomes unstable and divides into two (rarely, three) parts termed fission fragment nuclei, which separate with enormous energy, propelled by their mutual electrostatic repulsion. The

(1) Nuclei, stability and sizes

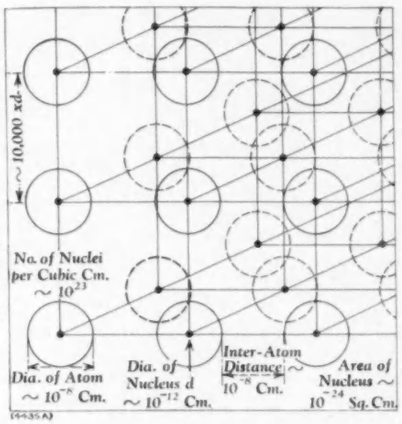

~ 10,000 xd.
No. of Nuclei per Cubic Cm. ~ 10^{23}
Dia. of Atom ~ 10^{-8} Cm.
Dia. of Nucleus d ~ 10^{-12} Cm.
Inter-Atom Distance ~ 10^{-8} Cm.
Area of Nucleus ~ 10^{-24} Sq. Cm.

Fig. 1 Representation of crystal lattice.

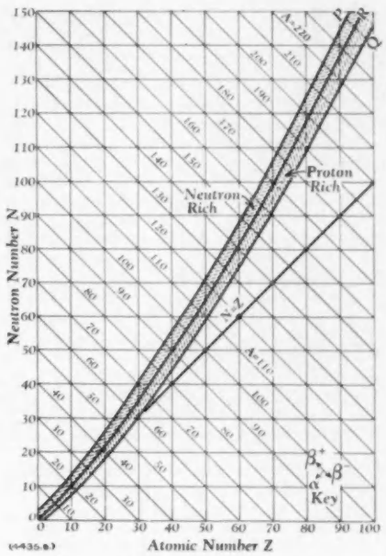


Fig. 2 Stable and radioactive nuclei.

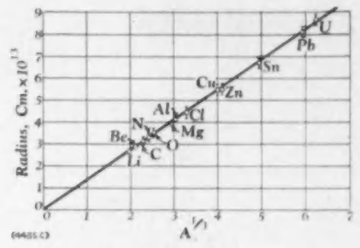
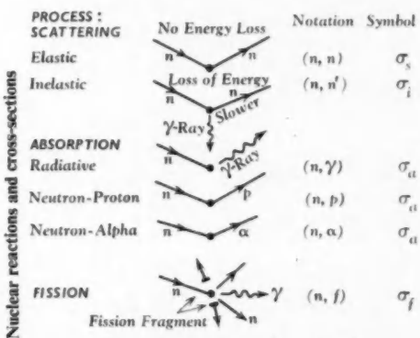


Fig. 3 Size of nuclei.

(2) Nuclear reactions and cross-sections



Total Cross Section = Sum of Cross-Sections = σ_T for all Processes in a Nucleus

Note:- In Reactor Equations σ_a Usually Denotes Sum of All Absorption Processes, Including Fission

Fig. 4 Neutron-nucleus interactions.

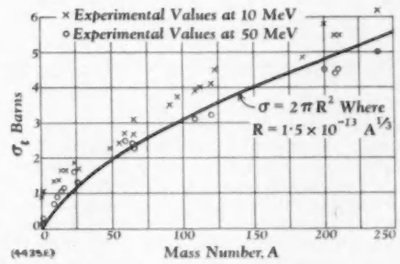

× Experimental Values at 10 MeV
○ Experimental Values at 50 MeV
$\sigma = 2\pi R^2$ Where
$R = 1{\cdot}5 \times 10^{-13} A^{1/3}$
σ_t Barns
Mass Number, A

Fig. 5 Total cross-section at high energies.

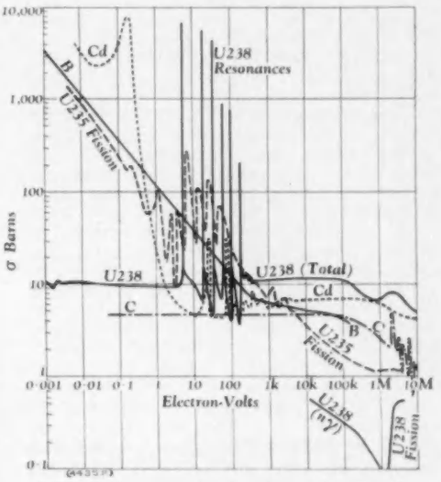


Fig. 6 Cross-sections (see enlargement, page 726).

(3) Nuclear fission

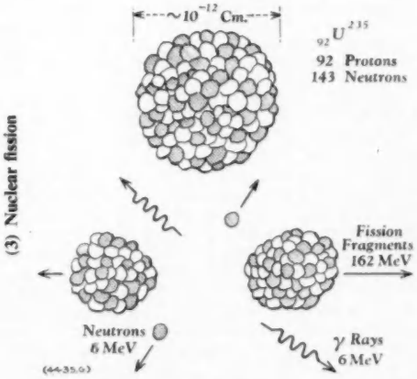


Fig. 7 The fission phenomenon.

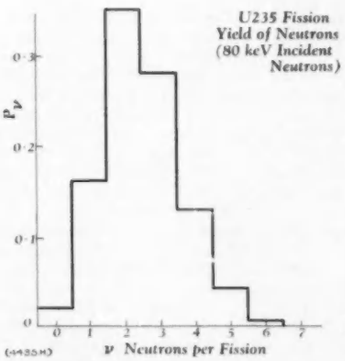


Fig. 8 Number of neutrons per fission.

(4) Yield of neutrons from fission

ν = Number of neutrons emitted per fission.

$\alpha = \frac{\sigma_a}{\sigma_f} = \frac{\text{Non-fission capture cross-section}}{\text{Fission cross-section}}$.

η = Number of neutrons born per neutron absorbed in fissile material = $\frac{\nu}{1+\alpha}$.

Values for fission by thermal (0·0253eV) neutrons

Fissile isotope	ν	α	η
U233	2·52	0·105	2·28
U235	2·47	0·192	2·07
Pu239	2·91	0·39	2·09

Fig. 10 Neutron yield constants.

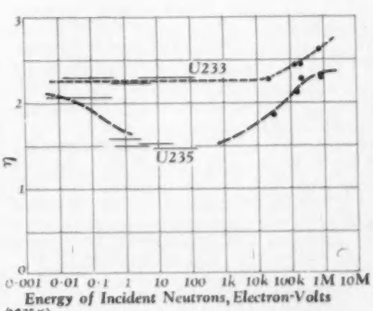


Fig. 11 Variation of η with energy of incident neutron.

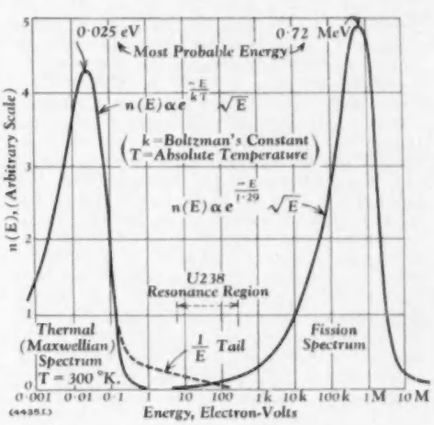


Fig. 9 Fission and Maxwellian thermal spectra.

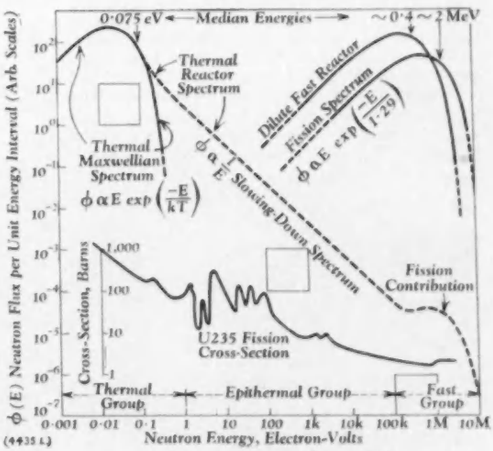


Fig. 12 Neutron flux spectra.

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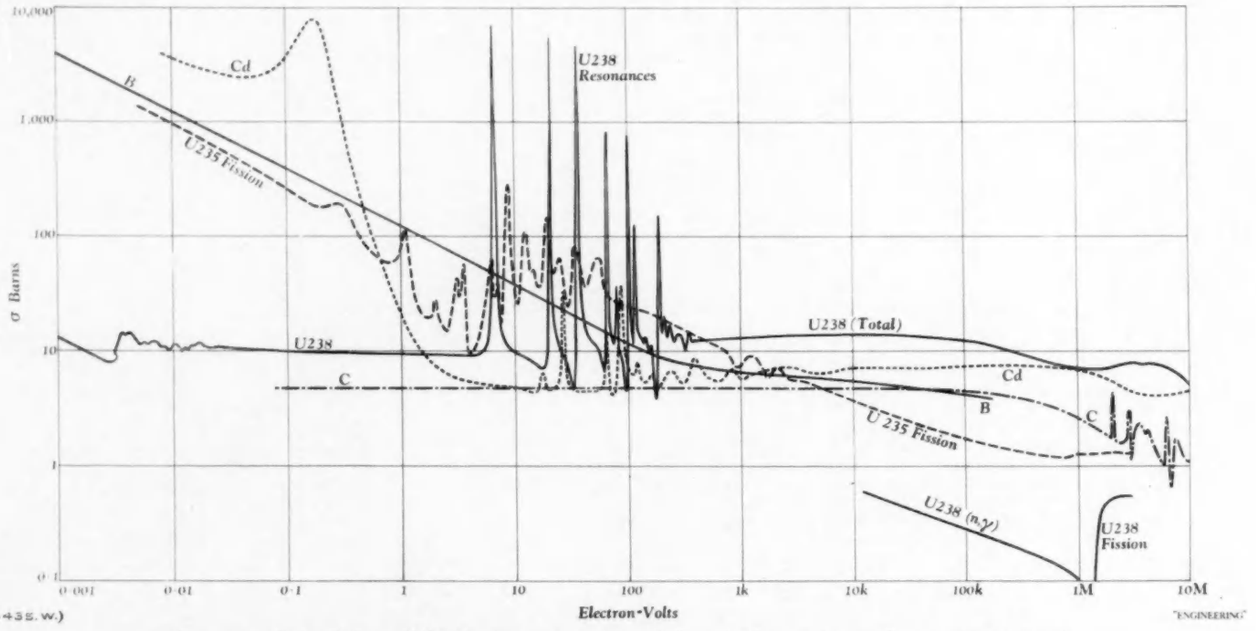

Enlargement of Fig. 6 (page 725) showing cross-sections of elements important in nuclear reactor engineering.

two new, lighter nuclei do not need so many neutrons between them (see Fig. 2), so that some of the surplus are "coughed out" promptly at the moment of fission. A few more (less than 1 per cent. of the total) are emitted by some of the still-neutron-rich fission fragment nuclei at times up to minutes after the instant of fission. These are the delayed neutrons important to reactor control.

A single fission produces approximately 200 MeV of energy, most of which is the kinetic energy of the fission nuclei. This is some 30 million times the energy per atom consumed in a chemical reaction (for example $2\,Mg + O_2 \rightarrow 2\,MgO + 6$ eV per event), but even so is but a tiny quantity of energy on the everyday scale: for $3{\cdot}1 \times 10^{10}$ fissions *per second* are required to produce 1 watt of heat energy. The heating effect from fission is mainly due to the rapid transfer of kinetic energy from the fission fragments to neighbouring nuclei with which they collide, slowing down to rest in the process. The fission fragment nuclei gather their appropriate complement of electrons and become electrically neutral (but radioactive) atoms, lodged interstitially in the crystallite lattice of the solid material within a few thousandths of an inch of the site of the fission event.

Number of Neutrons per Fission (*Fig.* 8).—A particular fission event may produce any (whole) number of neutrons between zero and eight. What matters for reactor operation is the average number (ν) produced per fission from a very large number of fission events. This varies from one fissile isotope to another and is listed for the three fissile isotopes of technological importance in Fig. 10.

The Fission and Thermal Spectra (*Fig.* 9).—The majority of neutrons born in fission possess MeV-order energy at birth: the most probable energy is about 1 MeV, the average energy about 2 MeV. The fission spectrum is here plotted in terms of the number of neutrons per unit energy interval (that is per eV of energy range), against energy.

Notice that although the actual area of the spectrum below 1 MeV appears on the diagram larger than the part above 1 MeV, this is because it has been plotted on a logarithmic energy scale which exaggerates the low-energy areas. The "thermal" spectrum at the low-energy end of the scale represents the energy distribution of neutrons which are diffusing within a scattering substance in thermal equilibrium with the nuclei of the scattering atoms: there is equi-partition of energy as between neutron translation and atom vibration, and on the average the neutrons lose no energy during the diffusion process. It has been seen that the fission cross-section of U235 is large over this energy range, and it may therefore prove profitable in some applications to slow down the high-energy fission neutrons to the thermal-energy range to increase their chance of causing fission.

This slowing down is usually done using a "moderating" substance, for which application there are four practicable candidates which meet the combined requirements of low absorption cross-section, low atomic weight and, if possible, large scattering cross-section. The substances are hydrogen (in water), deuterium (heavy hydrogen) (in heavy water), beryllium (metal or oxide) and carbon (as graphite). (Carbon and hydrogen are of course combined in organic moderators.) If fission neutrons are allowed to enter these substances they are slowed down (reduced in energy) until, if not absorbed too quickly, they reach thermal equilibrium with the moderating substance.

If in addition to the slowing-down process neutrons are continuously being removed when thermalised (absorption to cause fission) and renewed by a supply from fission, there will be added to the thermal equilibrium spectrum a steady-state slowing-down spectrum, representing the concentration of neutrons at the various energies during the slowing-down process. Analysis shows that the neutron flux per unit energy interval in this region is usually proportional to 1/E (see Fig. 12). The fission spectrum shown is not supposed to co-exist with the 1/E and thermal spectrum at the amplitude shown. If drawn on the same linear scale as the thermal spectrum in this figure the fission spectrum would be invisibly small, for all the neutrons born over the huge energy range up to ~ 10 million eV (neglecting losses during slowing-down) would have to be accounted for in the area of the curve up to 1 eV plus the 1/E tail; areas are related by a factor of about 100 million.

(4) Yield of Neutrons from Fission

Neutron Yield Constants (*Fig.* 10).—The quantities defined and listed on Fig. 10 are of importance to the neutron economics of various possible reactor schemes. It should also be noted that α becomes smaller for high energy neutrons, thus giving larger values of η. This is one of the main reasons for the interest in fast fission reactors.

Variation of η with Energy of Incident Neutron (*Fig.* 11).—The variation of η with neutron energy is a direct consequence of the variation in α but it is also affected by the fact that ν increases slightly as the incident neutron energy is increased. The curves in Fig. 11 show that it would be unprofitable to operate a U235 reactor in the epithermal regions (see Fig. 12), but that U233 could be considered for this purpose. Both U233 and U235 show distinct improvements in the fast-neutron region.

Neutron Flux Spectra (*Fig.* 12).—The fission and thermal neutron energy spectra shown in Fig. 9 are shown again here on a log-log plot of neutron *flux* per unit energy interval [ϕ (E) = n (E) v (E)] instead of neutron concentration per unit energy interval, n (E). (The concept and use of neutron flux is discussed in section B2 below.) The spectrum within a typical fast power reactor (design) is also shown, with a median energy of 0·4 MeV. Notice how small the U235 fission cross-section is over the important part of this spectrum; this leads to the very large critical mass of fast reactors. Notice also that the three squares each contribute equal effective areas to the integral $\int^{E} \phi\,(E)\,dE$, the integrated reactor flux. However, the relative importance of the high-energy areas is usually reduced by the relatively smaller absorption or fission cross-sections in the high-energy regions.

The second part of this article, to be published next week, will provide a more detailed examination of certain physical concepts fundamental to reactor design, including neutron multiplication, mean free path and neutron diffusion. Later sections will be devoted to such specific topics as the idea of critical size and the range of practicable reactors; the theory of the neutron slowing-down process with reference to such concepts as resonance escape probability and the fast fission factor; the calculation of critical size, dealing with the Fermi age model; the reflected reactor and group theories; and the determination of breeding ratio.

FAIL-SAFE AIRCRAFT PRESSURE CABINS

Hoop Reinforcement Limits Cracking

Post-war airline experience has shown that no type of aircraft structure has yet been put into service that is immune from accidental cracking—which may be harmless if detected in time by the maintenance staff, but which in some cases has resulted in catastrophic failure in the air. This has led aircraft structural designers towards the "fail-safe" concept, in which the aim is to design a structure which will continue to operate safely even with undetected damage.

Among others, the Royal Aircraft Establishment have been working on this problem, and they have recently conducted tests on a Comet I pressure cabin which had been modified to incorporate a new construction. The method, the tests and the implications of the results are discussed in Aeronautical Research Council Current Paper No. 357, by Dr. D. Williams, "An Experimental Verification of the Theoretical Conclusions of R.A.E. Technical Note No. Structures 156 (A.R.C., C.P. No. 286), 'A Constructional Method for Minimising the Hazard of Catastrophic Failure in a Pressure Cabin' with Further Comments on its Implications" (H.M.S.O., 2*s.* 6*d.*).

Practically all airliner cabins in service to-day, or currently under construction, comprise skin reinforced longitudinally by fairly closely-spaced stringers with transverse frames spaced 18 to 20 in. apart. In such a structure, midway between the frames the skin is "unaware" of the constraining effect of the frames and carries practically the same hoop stress as it would if there were no frames at all. Dr. Williams' analysis has shown that, if the skin were further reinforced by transverse rings spaced about 10 in. apart, then, by virtue of the bending stiffness of the bridging stringers, the skin is restrained from radial expansion and the maximum hoop stress is thereby greatly reduced—"material put into the rings is almost equally effective in reducing the maximum hoop stress in the skin as material used to increase the thickness of the skin itself." As an example, he cites a conventional fuselage in which a skin thickness of 0·044 in. would be required to withstand the maximum hoop tension: under the new scheme of construction the designer could use, say, a skin 0·024 in. thick and the remainder of the material would go to provide hoops of cross-sectional area 0·2 sq. in. pitched 10 in. apart. The advantage of this type of structure is that, if a crack does occur in the skin, before it can spread to an uncontrollable length it comes up against a hoop which forms a most efficient crack arrester; and such cracks tend to develop progressively and not disruptively.

In these tests, a Comet I fuselage was reinforced by external hoops 1·2 in. wide by 0·128 in. thick; some were spaced at 10 in., some at 16 in. and others at 21 in. pitch. An artificial longitudinal split was introduced into the skin, and the cabin was subjected to repeated pressure cycles from atmospheric to 8·25 lb. per sq. in. above atmospheric. Where the hoops were spaced at 10 in. pitch the tests showed that, even with a 5 in. crack in the skin, the structure would withstand 250 to 300 loading cycles before the crack started to spread, progressively and not suddenly, to the adjacent hoops where it was arrested so effectively that, after 1,400 cycles, it had not extended into the adjacent bays. In the tests at 16 in. pitch and at 20 in. pitch, where the constraining effect of the rings was less effective in reducing the stress in the skin, the cracks ran rapidly across the panel after they had attained a length of about 10 in. and 8¼ in. respectively—although in every case the hoops stopped the cracks from spreading into the adjacent skin panels.

"The suggested new method of construction makes the possibility of catastrophic failure of a pressure cabin remote enough to be ruled out," is Dr. Williams' conclusion; and he considers that "careful and frequent examination of the cabin shell for cracks becomes unnecessary since they can be safely left until spotted . . . in ordinary maintenance inspection." (Air travellers may perhaps hope that the airline engineering organisations will take a more conservative view!) The new type of fuselage should be no heavier and should have an effective life at least five times that of the conventional construction—because the life of the latter is based upon the results of a tank test of a single airframe specimen, and a factor of at least five is imposed upon the test life to take account of statistical scatter. The tank test will, Dr. Williams considers, no longer be necessary, although it may be a useful means for discovering weak points in the design.

Dr. Williams feels strongly that the hoops should be outside the cabin shell, as they were in the Comet tests—and in this he has the support, at any rate in principle, of the chief engineer of Bristol Aircraft Limited who said at the Anglo-American Conference this year that "no one would dream of making a beer barrel with internal straps." It has, however, still to be demonstrated that external hoops will not have a prohibitive effect on fuselage drag—flight tests are in fact to be carried out at Farnborough to determine just what the effect is—and it may well be that aircraft designers will prefer to adopt a less satisfactory structural solution than to sacrifice performance.

As regards cabin windows: Dr. Williams, considering windows of more or less conventional size, advocates carrying the reinforcing hoop right across the window. There is, however, already a design trend towards more and smaller windows because the most usual current arrangement of a window between every alternate pair of transverse frames, can, in these days of variable cabin seating layouts, result in an uncomfortable crick in the passenger's neck; and if the 10 in. hoop spacing is adopted in future designs, it might lead to an arrangement of closely-spaced peep-holes in place of the cabin windows as they are known to-day—which would, at any rate, eliminate some of the hazards associated with window failure.

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BRITANNIA SEEKS MONSOON ICE

A Britannia 312 long-range aircraft of Bristol Aircraft Limited has recently left for Singapore, from where, during the next few weeks, it will make an intensive series of weather exploration flights. The aircraft is fitted with Proteus 755 engines incorporating two forms of modification designed to eliminate the engine-icing problem encountered in certain monsoon conditions, where very high humidity and tropical temperatures result in a high concentration of dry ice mixed with water droplets, at altitudes ranging from approximately 16,000 ft. to 20,000 ft. at ambient temperatures of zero to − 8 deg. C.

In the two outboard power plants, multiple nozzles fitted to the outer wall of the intake duct direct jets of air along the inner surface of the rear wall of the intake in order to accelerate the boundary layer and so prevent ice accumulation. There are 25 of these air jet nozzles spaced about 6 in. apart, supplied by a manifold encircling the intake. The air is fed to the manifold from the cabin air-pressure tapping off the final stage of the engine compressor.

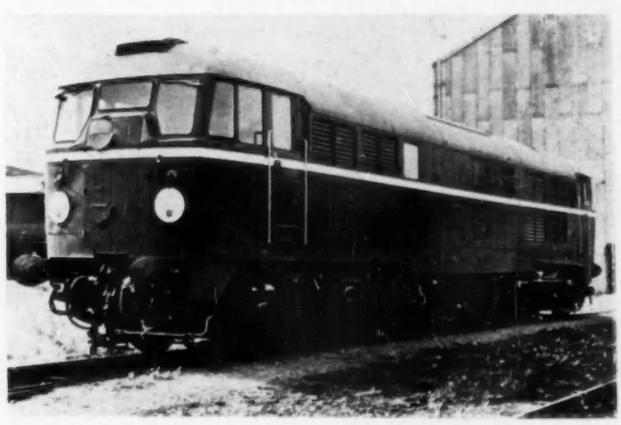
The amount of air tapped from the compressor is about ½ lb. per sec., resulting in a cruising altitude about 1,500 ft. lower and a 2 per cent. loss of range while the system is in operation.

On the two inboard engines, the walls of the air entry duct will now be heated by gas at 280 to 300 deg. C. instead of the standard 180 deg. C. The hot gas is fed to the rear of the curved wall of the air intake at the bend directing the air into the engine compressor. The distribution of the hot gas has also been improved.

MAIN LINE DIESEL LOCOMOTIVES

The first of the 1,250 h.p. Diesel-electric locomotives to be delivered to British Railways was handed over to the Eastern Region on October 31. It is shown in the illustration below. It has been manufactured by Brush Traction Limited, Loughborough, and is the first of 20 on order from that firm. They are designed for mixed traffic use and will be employed on the Great Eastern line, centred at Stratford, but will be tried out as necessary in other areas.

The locomotives have the A1A-A1A wheel arrangement, and each weighs 104 tons in working order. They are capable of a maximum speed of 75 miles an hour, and can be used on passenger service as they are fitted with a train heating oil-fired steam boiler. The driver has a cab at both ends and two locomotives can be driven in tandem if required. Power is supplied by a Mirrlees type JVS 12T engine, which is rated for 1,250 b.h.p. at 250 r.p.m. It is directly coupled to a 823 kW Brush generator producing current at 686 volts. Four traction motors are mounted in the Commonwealth type cast steel bogies. The length of the locomotive over buffers is 56 ft. 9 in., and the bogies are set at 28 ft. 10 in. centres. On starting, the tractive effort is 42,000 lb. (26 per cent. adhesion) falling to a continuous rating of 22,400 lb. at 16·5 m.p.h. Hoffman bearings are used in the axle boxes. The controls have been arranged so that automatic train control equipment can be fitted at a later stage if required.



The first of the 1,250 b.h.p. mixed traffic Diesel-electric locomotives under the modernisation plan, has been handed over to the Eastern Region.

Production

NATURAL GAS IN GREAT BRITAIN

Saving over 1,000 *tons of Coal a week*

Natural gas only occurs to a limited extent in this country, but in certain localities it is worth exploiting. Two schemes for putting it to use have recently been formally inaugurated. One, in Scotland, taps the gas from a bed of porous limestone, while the other, in North Staffordshire, makes use of methane drained from a colliery. In both cases the gas is piped to nearby gasworks of the local Gas Board, where it is mixed with the normal production of coal gas and fed into the public mains.

At Cousland, in Scotland, an anticline of non-porous rock seals off a bed of porous sandstone in which the gas has collected. When the non-porous envelope is pierced by a well or borehole, gas is released at high pressure. The gas, which consists of 94 per cent. methane or associated gases and 6 per cent. nitrogen, contains no sulphur, and has a calorific value of 930/960 B.Th.U. per cub. ft. It is tapped by means of a well 1,600 ft. deep, and the gas pressure at the well head is approximately 620 lb. per sq. in.

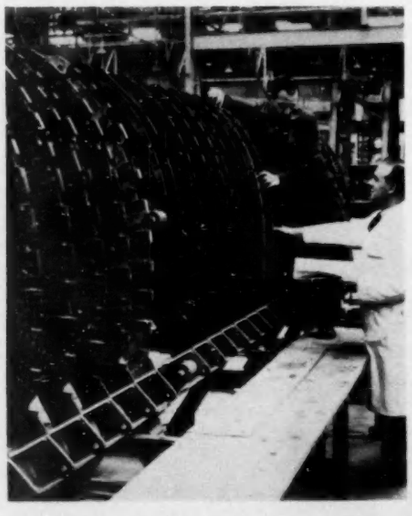
The well terminates at ground level in a 2 in. diameter tube surrounded by an 8¾ in. diameter casing. Valves and branches at the top of the 2 in. tube enable the gas to be distributed to a high-pressure water separator (provided in case water should be present at a later date), to a burning line for production testing, and to a governor house for transmission to the gasworks. At the governor house the gas pressure is reduced in three stages from 620 lb. to 3 lb. per sq. in., at which figure it enters a 4 in. diameter main, 8,400 yards long, leading to Musselburgh Gas Works of the Scottish Gas Board. The gas does not have the characteristic odour of coal gas, and provision is made at the Cousland well site for the addition of an odorising agent, tetrahydrothiophene.

On arrival at Musselburgh the natural gas passes through a governor to reduce its pressure to that of the gas manufactured in the works, and it is then metered into the coal gas stream. The mixture is then measured and passed to a gas-holder for storage before distribution. Instruments are provided for measuring the calorific value of the natural gas, the manufactured gas, and the mixture entering and leaving the gas-holder. In addition, remote control instruments at Musselburgh show the governor house pressures and flow meter readings at Cousland. Musselburgh coal gas has a declared calorific value of 450 B.Th.U. per cub. ft. This is reduced by adjustments in the retort house to allow a proportion of the 960 B.Th.U. natural gas to be mixed with it, and so to retain the declared value in the public mains. Reduction of calorific value in the manufactured gas will reduce the amount of coal used, and it is calculated that one ton of coal will be saved at Musselburgh for every 7,000 cub. ft. of natural gas used.

The North Staffordshire scheme, operated jointly by the West Midlands Division of the National Coal Board and the West Midlands Gas Board, is based on the drainage of methane gas from Wolstanton Colliery, Stoke-on-Trent, and its mixture with coal gas manufactured at the nearby Etruria Gas Works. This is the first stage of a scheme which will, next year, also take methane from Holditch Colliery, and can be extended to other North Staffordshire collieries later as circumstances permit. In the present stage the intention is to give a minimum supply from the two collieries equivalent to 5 million cub. ft. a week of pure methane. As the calorific value of pure methane is double that of the same volume of gas made by carbonising coal, the supply will be equal to 10 million cub. ft. of coal gas. The estimated saving by the middle of next year is about 1,000 tons of coal a week.

The methane piped to Etruria Gas Works, which is not pure, has a calorific value of about 700 B.Th.U. per cub. ft., and it is mixed with the manufactured coal gas stream simply by a connection of one main with another, the mixture being controlled to maintain the public gas supply at its declared value of 470 B.Th.U. per cub. ft.

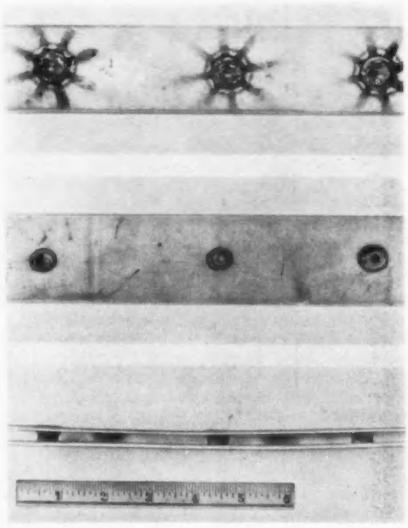
Methane has been drained from collieries for many years and has been used in various ways on a limited scale. Two methods are used in North Staffordshire. In the one, gas is drained from the goaves, or worked-out parts of the mine, by means of controlled-pressure chambers at the entrances to the worked-out districts. Gas is drawn off through pipes at rates appropriate to its rate of production, and variation in barometric pressure. In the second method, cross-measure borehole working, boreholes 2 in. to 3 in. diameter and up to 300 ft. long are driven at an angle, sometimes behind and sometimes in front of the working face, and sometimes downwards from the roadways leading to the face. The boreholes and the pressure chambers are connected by pipes taking the gas to the pit bottom and thence up the shaft to the surface. Suction pumps are used to assist the gas flow when necessary.



Assembly jig on which the fuselage side panel of the Bristol twin-rotor helicopter is produced, showing some of the formers fabricated from Bakelite laminate grade P992.

PLASTICS TOOLING FOR HELICOPTERS

In the production of Bristol 192 twin-rotor helicopters, extensive use has been made of Bakelite P992 paper-based laminate, supplied by Bakelite Limited, 12-18 Grosvenor-gardens, London, S.W.1, in jigs and fixtures employed in the assembly of the helicopter air frames. Formers machined from the laminated material, bolted to steel angle and connecting plates, are used for the main assembly fixtures and for the upper and lower fuselage panel fixtures, all of which are about 24 ft. long. The laminate is also used for nose-forming assembly fixtures and cabin-door assembly jigs. In tooling applications of this kind the laminated material offers the advantages of being light (one-sixth the weight of mild steel), strong and hard-wearing, and it can be readily machined with standard wood- or metal-working tools. In addition, it is dimensionally stable and resistant to water and most chemicals.



Standard spot-welding equipment is used in the Sigma "space-welding" technique, which produces spacers of weld metal.

JOINING SPACED METAL SHEETS BY WELDING

A new technique, known as "space welding," introduced by the Linde Department, Union Carbide International Company, 30 East 42nd-street, New York 17, N.Y., U.S.A., enables sheets up to ⅛ in. thick to be joined, with gaps between them up to twice the thickness of the bottom sheet. It uses standard Sigma spot-welding equipment, and requires a minimum of material preparation, being entirely different from projection or plug welding. Any material which can be Sigma welded can be joined with the possible exception of aluminium.

In the new method a delayed wire feed is used with standard Sigma equipment and argon shielding gas. The arc melts a hole through the top sheet and fuses the molten metal to the lower sheet. Then a column of metal is built up until it fills the hole and fuses with the top sheet. No preparations are necessary, other than the insertion of removable spacers between the two sheets. In some cases only single-cycle welds are needed, while in others, particularly as the spacing increases, double-cycle welds are required. The spacers formed between the sheets are uniform, and good fusion is obtained on the lower sheet, though it is not necessarily equal to the diameter of the spacer at that point.

High rigidity in the assembly results from this method of welding. For example, a load of 412 lb. was needed to produce a deflection of ½ in. on a space-welded assembly of $\frac{1}{16}$ in. carbon steel sheets, while 212 lb. sufficed for the same deflection on a single sheet ⅛ in. thick. The assemblies also have a greater bursting strength than those produced by projection or plug welding.

HANDLING STEEL STRIP

An attachment for fitting to a fork truck has been produced by Lansing Bagnall Limited, Kingsclere-road, Basingstoke, Hampshire, for the particular purpose of handling coils of steel strip. The head consists of a main spigot which is slightly less in diameter than the bore of the smallest coil to be handled, having a moveable section that can be expanded to grip the inside of the coil. The action of this gripping shoe is effected hydraulically. Coils of approximately 30 cwt. each can be handled by the truck up to its full lift height; in conjunction with specially designed storage racks, considerable space saving is possible, while maintaining ease of handling and selection of the strip coils.

Automobile Engineering

SAFETY BELTS FOR AUTOMOBILES

Within the last few years interest has grown in the possibilities of safety belts for the protection of drivers and passengers in automobiles from the worst effects of head-on crashes, in which the occupants may be thrown bodily against the windscreen or hurled from the car. Several safety belts of this kind are now commercially available—not all of which, however, give satisfactory protection, as has been brought to light by tests carried out by the Swedish State Power Board, Stockholm. The results of the tests, and design criteria for an effective safety harness, are described in a report issued recently by the Board on *Safety Belts for Motors*, by Bengt Odelgard and Per-Olof Weman.

In the first test carried out by the Swedish investigators, a nylon harness of the type shown in Fig. 1, the straps of which were 4·5 mm. thick by 45 mm. wide, was tested on a jointed dummy figure designed to simulate the weight distribution of the human body. The dummy was seated in the front seat of a 1938 Hudson Terraplane car; the harness was secured by an eyelet to a point below the front of the rear seat. The car was dropped from a height on to its nose, the height being chosen to give an impact speed of 60 km. per hour. Mechanical accelerometers located on the starboard chassis frame member and cylinder block indicated an impact deceleration of 136 *g*, while an accelerometer on the port frame member recorded 95 *g*. Photographs by a high-speed ciné camera provided an analysis of the crash process from which deceleration/time curves were deduced for the automobile, the seat, and the dummy's hips and shoulders. These records showed that the rebound movement of the dummy's shoulders was four times that of the car itself, and the deceleration of the shoulders was much higher than that of the car as a whole (Fig. 2), due to the load/elongation relationship of the nylon harness under test. As the speed of the dummy fell to zero, the maximum strain in the harness,

Fig. 1 The nylon harness tested; neither the material nor the arrangement proved adequate.

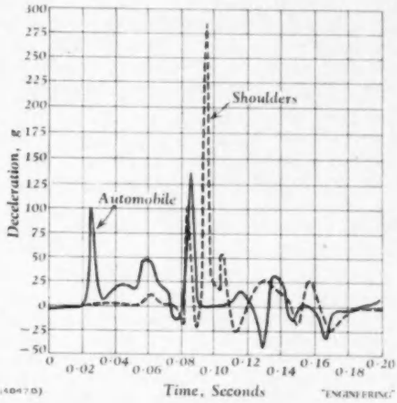


Fig. 2 Deceleration/time curves derived from a drop test.

in combination with the low hysteresis of nylon, gave rise to a pronounced slingshot effect, catapulting the dummy back against the seat so violently that, had it been a living person, his neck would probably have been broken.

The unexpected result of this test led the Swedish investigators to carry out a further series of crash tests, on a specially-built rig, on 11 different safety belts—none of which fully met the requirements of the ideal deceleration/elongation diagram—this diagram being computed on the basis of the decelerations, and rate of deceleration, that the seated and harnessed human body can stand, as determined by U.S. Air Force tests (45 *g*—and possibly as much as 100 *g*—but decelerations above 25 *g* must not last longer than 0·25 sec. if body tissues are to remain undamaged; and the rate of deceleration must not exceed 1,300 *g* per sec.). In the Swedish tests, almost all the linen belts snapped under stress, and generally the nylon belts gave substantial rebounds. Moreover, it was found that the strength of ordinary automobile seats is quite low, and that they can be crushed by improperly placed safety straps. Another fault was the jamming of the belt clasp due to distortion under impact load.

The team then set out to design a satisfactory belt. The best basic material to give the desired characteristic was, they found, rayon; a weave of stainless steel filaments and nylon, in the ratio of 1·5 to 1, was also found to give the desired elongation diagram. A harness comprising both hip and chest belts gives the best all-round protection, but a chest belt alone is adequate, and, for simplicity, their final design of belt is of this type, with two straps held together by a quick-release mechanism. The attachment points to the car have been chosen to provide the maximum possible protection against head and chest injuries. The design conditions for the Swedish Power Board belt are summarised as follows: " rupture strength and elongation shall accord with the ideal diagram. Positioning of belt shall provide protection for vulnerable areas of the body. Belt shall be positioned so as to avoid placing stress on the car seat. Safety belt gear shall not encumber movements of rear seat passengers. Belt shall be fitted with quick release clasp (emergency release). Belt shall be kept within easy reach. Belt shall be easy to clean."

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I.C. ENGINE TESTS: USE OF STATISTICS

An interesting group of three papers on the testing of internal combustion engines was presented to the Institution of Mechanical Engineers on Friday, November 1. They dealt respectively with the equipment for engine testing, the testing of new engine types to assess their reliability, and the application of statistics to engine performance tests.

The first paper, by Mr. H. Freeston of the Shell Company's Thornton Research Centre, described the layout of engine test rooms, the design of vibration-absorbing mountings, arrangements for metering fuel, oil and water, dynamometers, and the instrumentation needed to record engine characteristics, exhaust gas analysis, temperature and the like. The paper concluded with some notes on the automatic control of an engine which is required to run at a cycle of loads and speeds and an account of the recently introduced method of detecting engine wear from a selected part by measuring the radio-activity transferred from that part to the sump oil. Although this paper did not contain any new information it forms a really useful summary of the present position of the engine tester's art, inevitably biased by Mr. Freeston's obvious interest in oils and fuels rather than the mechanical aspects of engine testing.

Lt.-Col. R. A. Lawrence and Mr. W. H. A. Collins described the testing, for the Ministry of Supply, of new internal combustion engines which may be introduced into the Services. These tests combine a straightforward run, to show that the engine would not break down at less than the prescribed number of hours working under given conditions, with stripping and examining the engine after the test period to look for any abnormal wear which would be indicative of a poor service life. The procedure seems to have one weakness in that the Services are really interested in the distribution of failure over a large number of engines of nominally identical construction, yet tests on a few engines are probably all that can be afforded. It was recently shown that the life between breakdowns of similar machines will vary widely,* but that if a sufficient number of breakdowns, either in different machines or, if wear is reasonable, successive breakdowns of the same machine, will enable the likelihood of breakdown of the machine in a fixed duration run to be ascertained.

The third paper presented was by Dr. W. R. Buckland who is a statistician working with London Transport. While every engineer to-day accepts the need to use statistical methods in his work, it is unfortunate that few statisticians are able to present their conclusions in such a simple manner as to induce ready acceptance from the engineer. It is doubtful whether many engineers will appreciate Dr. Buckland's paper which, apart from the useful definitions at its beginning, might well have been published in a specialist statistical journal. The task of inducing engineers to employ statistical methods might be more efficiently achieved by the use of simple examples as used by Davies.†

* G. Morris, ENGINEERING, July 12, 1957, page 41.
† O. L. Davies, *Statistical Methods in Research and Production*, Oliver and Boyd, 1957.

SPEED CHECK

An electronic equipment for measuring what is virtually the instantaneous speed of a road vehicle has been developed by Venner Electronics Limited, Kingston By-pass, New Malden, Surrey. It is at present being tested by the Metropolitan Police on outer London roads.

The two rubber tubes which control the timing cycle span the width of the road at a distance of 70·4 in. apart. Each is connected to a pressure switch, one for starting the timing circuit and the other for stopping it. Three decade counters measure the number of pulses passing during the time interval which elapses between the operation of the two switches.

The pulses used to trigger the counters are derived from a 10 kc/s oscillator which feeds two binary dividers to give a 2·5 kc/s signal. This in turn is fed to a gating circuit which is opened and closed by the two pressure switches. The equipment was primarily developed for the Road Research Laboratories as a high accuracy device for measuring small intervals of time. Transistor circuits are used throughout, embodying in all some 54 transistors. The pulse frequency and the distance apart of the pressure tubes have been chosen so that the recorded number, when divided into 10,000, gives the speed of the vehicle. The error is $\pm$ 1 per cent. at 100 m.p.h. and $\pm$ ½ per cent. at 30 m.p.h.

It is expected that the rubber tubes may be laid semi-permanently at points known to be black spots and the equipment, which only measures 13 in. by 9 in. by 7 in. complete with batteries, plugged in from time to time so that speed checks can be made at irregular intervals.

Atomic Review

Reactor Flux

It has been suggested—though not very seriously—that whatever new fuels may be discovered, there will never be any striking reduction in the cost of electric power. Coal and oil are relatively expensive fuels, but may be burned in comparatively inexpensive plants; uranium and thorium, though cheap, require for their consumption plants of high capital cost. Similarly, deuterium, which drips from every kitchen tap, may call for apparatus so costly that the advent of fusion power may leave us little better off—at least financially. Spurious though this argument may be, it does suggest that progressive technical refinement may sometimes be quite as profitable as basic discovery. The development of the fission reactor is still in a state of flux, and has far to go before it begins to show diminishing returns. The following notes discuss various proposals for improving the design and operation of nuclear reactors.

Choice of Coolant and Moderator

Probable coolant-moderator combinations for the first two stages of the United Kingdom atomic energy programme are given in the table below. The table appeared in a paper, "The Future of Nuclear Power," by Dr. J. V. Dunworth, recently presented before a meeting of the Institution of Gas Engineers.

Coolant	Moderator: Be	C	D	H
Gas	c	a	b	d
Heavy water	d	d	c	d
Light water or alternative liquid	d	d	d	b
Sodium	c	b	c	d

A system which might well go ahead now .. a,
Distinctly possible type of system .. .. b
Not a very likely system at present c
Not a likely system .. .. d

Fluidised Fuel Reactor

Reference has already been made in Atomic Review to reactors using a granular fuel supported by a gas stream. Reference was made to a high-temperature system of this kind in a paper "Fluid-Fuel Reactors for Nuclear Merchant Ships," recently presented before the American Society of Naval Architects and Marine Engineers by Mr. Cecil B. Ellis, of the Foster Wheeler Corporation. His main conclusions were summarised in Atomic Review last week. The fluid bed reactor has the virtue of being almost free from the formidable materials problems usual with high-temperature reactors. The reactor core is a fluidised bed of small thorium-plus-uranium 235 metal pellets, which is kept in the fluidised stated by the upward flow of helium coolant at about 30 ft. per second. The reactor is designed to produce emergent helium gas at 1,300 deg. F. (700 deg. C.) which can be transmitted directly to a gas turbine.

The use of helium eliminates the corrosion problems common to almost all other high-temperature coolants. The use of uranium in fluidised metallic pellets retains all the easy handling properties of other fluid-fuel reactors while by-passing the serious chemical troubles of every uranium bearing liquid at high temperature. In addition, radiation damage to the fuel is of very little importance, since the pellets do not remain in a fixed position, and it is of no consequence if radiation damage alters their size and shape, or causes some to split up. Also, the total heat surface area of the pellets is so great that the heat-transfer requirements for any element of surface area are very light. Fig. 1 sketches one way in which such a reactor might be constructed for a 20,000 s.h.p. closed-cycle gas-turbine ship-propulsion plant. The

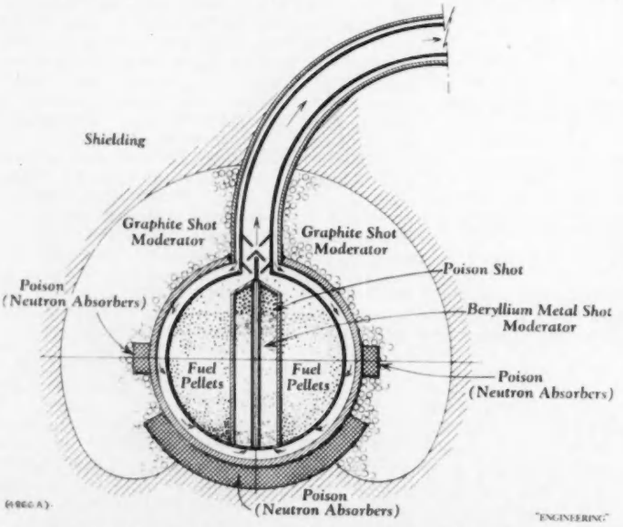


Fig. 1 Conceptual drawing of a core design for a high-temperature fluidised solid fuel reactor.

moderating material consists of small beryllium metal pellets in a central column, together with graphite pellets arranged as a moderating reflector outside the pressure shell. Material containing a strong neutron absorber is placed below the core to keep the bed subcritical when the coolant is not flowing and the bed is at rest on the bottom.

The reactor maintains its stability automatically in much the same fashion as does a boiling-water reactor. The normal rate of power production leads to about a 40 per cent. increase in velocity of the helium during its passage through the core. Any random reactor power increase will further increase the helium velocity increment and further expand the bed. This keeps the reactor subcritical because of reduced core density until it has returned to its original power. The reactor therefore needs no control rods. Changing the helium gas inventory in the loop or throttling or partially by-passing the turbine causes the reactor power to vary automatically according to the ship's needs. The small randomly shaped pellet system also permits this reactor to be just as economical as the liquid-fuel systems with respect to time needed for changing fuel and ease of fuel processing.

Fluidised Reactor with Carbon Moderator

The feasibility of power reactors using a circulating gas-fluidised solids system is discussed in a report published by a branch of the Foster Wheeler Corporation. Carbon moderator particles, impregnated with uranium 233, flow as a settled bed through a carbon reactor core. A fluidised thorium carbide blanket is maintained outside the core. The system was found to be impractical for the following reasons: (1) a boiling fluidised bed undergoes rapid and large bulk density changes, (2) a quiescent bed cannot be maintained in a reactor core, (3) a uniform particle density is difficult to maintain at high temperature, (4) the attrition rate of graphite is excessive, and (5) the temperature coefficient of reactivity is insufficient to provide adequate control. (Diamond Alkali Co. and Pioneer Service and Engineering Co.) This note and certain others have been taken from the United States Atomic Energy Commission's *Nuclear Science Abstracts*.

Sodium Reactor Experiment

The Sodium Reactor Experiment (SRE) at Santa Susana, California, U.S.A., was inaugurated last month by Mr. Lewis L. Strauss, chairman of the United States Atomic Energy Commission. Controls were operated whereby heat was passed from the reactor to a generating station built by the Southern California Edison Company. The electricity produced will be used in a local public system, and is said to be the first generated by a private utility with the aid of a non-military nuclear reactor. The reactor was built by Atomics International, a division of North American Aviation, Incorporated. The plant has an electrical capacity of 6·5 MW, and is the forerunner of a 75 MW nuclear power plant to be built under the Commission's Power Demonstration Reactor Programme for the Consumers Public Power District of Nebraska. The layout of SRE is shown in Fig. 2. Previous references to SRE appeared in Atomic Review last May 17 and June 14.

Nebraska Sodium Graphite Reactor

Mr. Lewis L. Strauss, chairman of the United States Atomic Energy Commission, recently announced that agreement has been reached with Consumers Public Power District of Columbus, Nebraska, on contract terms covering the construction and operation of a large-scale nuclear power plant at Hallam, Nebraska. Under the contract, the Commission, with specific assistance from Consumers, will construct a sodium-cooled, graphite-moderated reactor designed to produce 75 MW net of electricity. The public power group will provide the site and a 100 MW turbine generator, will contribute 5,220,000 dols. toward the costs of construction of the nuclear portion of the plant, and will operate the entire plant for five years. It is estimated that costs for construction of the reactor portion of the plant will be about 29,000,000 dols. The turbine generator facilities to be financed by Consumers will cost an estimated 11,000,000 dols. Consumers plans an additional expenditure of 10,000,000 dols. for a steam boiler, sub-station and other facilities at the Hallam plant. The Commission, in addition to financing the bulk of construction costs for the nuclear portion of the plant, has also agreed to bear pre-construction research and development costs estimated at about 18,000,000 dols. The major portion of this research and development work will be done by North American Aviation Incorporated under an existing contract with the Commission. The Commission has also agreed to bear post-construction costs, estimated at 8,000,000 dols. covering some fuel costs and extraordinary maintenance. Work on the first phase of the Nebraska project, covering the conventional turbo generator facilities, is expected to get under way early in 1958. These facilities are expected to be in operation, powered by conventional boiler facilities, by April 1960. Construction of the reactor facilities is expected to start in mid-1959, with testing scheduled for mid-1961 and full operation for late 1961.

Compatibility of Sodium and Other Materials

Experiments have been performed to determine the compatibility of graphite and molten sodium under various conditions. Effects such as corro-

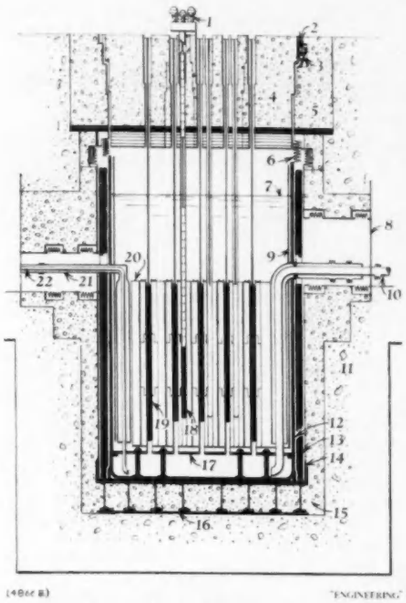


Fig. 2 Arrangement of Sodium Reactor Experiment

1. Control element drive. 2. Seal. 3. Roller. 4. Rotatable shield. 5. Ring shield. 6. Bellows. 7. Sodium level. 8. Diaphragm. 9. Inner liner. 10. Main sodium inlet line. 11. Biological shield. 12. Core tank. 13. Thermal shield. 14. Outer tank. 15. Thermal insulation. 16. Bearing plate. 17. Grid plate. 18. Control element. 19. Fuel element 20. Moderator element. 21. Guard pipe. 22. Auxiliary sodium inlet line.

sion, thermal shock, dimensional changes and penetration of sodium into the graphite pores were investigated. Significant corrosive attack on the graphite was noted only in the presence of carburisation of the container material. Stainless steel showed no appreciable carburisation below 550 deg. C., but carburisation was found at temperatures of 600 deg. C. and higher. Carburisation of zirconium was observed only at 750 deg. C. and higher. Graphite was found to be wet by liquid sodium above the level of the bulk liquid by capillary action. Experiments with previously irradiated graphite indicated no significant differences in behaviour from that of the unirradiated material. (North American Aviation Inc.: T. A. Coultas and R. Cygan.)

Fuel Elements to Permit Escape of Gases

A fuel-element container has been described, which is designed particularly for a liquid-sodium or sodium-potassium cooled reactor. Provision is made for stacked ring-like wafers of fissile material, interspersed with wafers of a neutron-moderating material, and passages capable of exhausting gaseous fission products formed from the fissile material during operation. These gases have a detrimental effect on the operation of the reactor as they absorb neutrons, and accumulate to a point where they substantially affect operations. The design is claimed to increase the efficiency and life of the fuel element. (H. Hurwitz: U.S. Patent No. 2,799,642.)

Another design also employs ring-like shapes of a moderating substance such as beryllium, separating or containing the fissile material. The rings have recesses designed to trap and contain any uranium powder released, as well as gaseous fission products. These recesses exhaust to a central passage thereby permitting the gases to be removed from the reactor while the powdered uranium is retained in the traps adjacent to the fissile material. The design therefore prevents a hazardous dispersion of uranium throughout the reactor by the circulation of the sodium coolant. (K. H. Kingdon: U.S. Patent No. 2,798,848.)

Intermittent Reactor Cooling

Heat may be removed from a reactor by intermittently cooling the reactor core. Mercury coolant is circulated through the reactor until the uranium temperatures fall to about 400 deg. C. The hot mercury is then passed to a heat exchanger or steam boiler and the neutronic reacton starts again as the mercury coolant is drained from the reactor. When the uranium rods or other fissile material within the reactor reach a desired temperature, about 600 deg. C., a pump starts flooding the reactor with mercury, stopping the reaction again. By adjusting the hot mercury flow in the boiler to give hot mercury storage, it is possible to have the steam boiler operate continuously. (L. Szilard: U.S. Patent No. 2,796,396.)

Twisted-Ribbon Core Assemblies

Twisted-ribbon fuel elements are a new concept for reactor core construction. The advantages of this approach are outlined in an Argonne National Laboratory report, together with a list of ribbon sizes and core designs now under consideration. A test programme was conducted to determine pressure drop through core assemblies of various geometries. Cold water and water-air mixtures were used to simulate two-phase flow conditions. The results are presented in tabular and graphical form. Attempts were made to correlate experimentally determined pressure drops with theoretical data. The pressure drop through twisted ribbon cores appears to be much less than originally anticipated and the empirical data presented permit reasonably accurate calculations of any proposed design. (Argonne National Laboratory: A. B. Schultz.)

Ribbon Fuel Element

During in-pile cycling tests on a uranium-zirconium alloy ribbon-type fuel element, the element became grossly deformed without concomitant cladding failure or release of fission products. (Knolls Atomic Power Laboratory: W. M. Cashin, B. Wimple and H. L. Zoch.)

Solid Homogeneous Reactors

It has been reported that three reactors to be built by the General Atomics Division of General Dynamics Corporation are to have cores comprising a solid homogeneous mixture of fuel and moderator. The uranium fuel will be of 20 per cent. enrichment and the moderator will be zirconium hydride. The system is said to be inherently safe, since if all excess reactivity is suddenly introduced, the reactor will shut itself down harmlessly. It is significant that Dr. P. Fortescue, who has been concerned in the study of the Very High Temperature (VHT) reactor using a solid homogeneous fuel-moderator mixture, has recently left Harwell for a period with General Dynamics.

The first of the three reactors, TRIGA, is to be a multi-purpose unit for training in reactor operation, research and the production of radioactive isotopes. The two others, REGA 10-30 and IRGA, are still in the design stage. IRGA will be an isotope producing reactor operating at a power level of 10 kW for the production of short-lived isotopes (half-life under 12 hours). IRGA and TRIGA may be built in pits 20 ft. deep and 6 ft. in diameter.

Homogeneous Graphite Reactor

The neutron physics involved in the engineering design of the North American Aviation homogeneous graphite research reactor (model S-5) are discussed in an N.A.A. report. This unit has a nominal operating power of 150 kW. It has a uranium impregnated graphite core and a graphite moderator, and it utilises heavy water as the primary coolant. A study is made of the effect of varying the quantity z (nuclei of uranium 235 per 100,000 nuclei of graphite) in the range from 5 to 20, upon the following items: critical mass, critical volume, minimum power to yield a thermal flux of 10^{12} per sq. cm. per sec. at the reflector peak, and temperature coefficient of reactivity. Several improvements in design and performance result from choosing z equal to 15. The temperature coefficient is somewhat impaired by this choice, and the prompt neutron lifetime is decreased. For an effective core volume of 0·94 by 16 cub. cm., criticality calculations are performed for four approximations of the core-reflector configurations. The most reliable result appears to be 3·53 kg. (cold), or 4·22 kg., including burn-up for a core lifetime of $3{\cdot}5 \times 10^8$ kWh., warm-up, fission-product poisoning and experimental facilities. The total reactivity to be controlled is about 9½ per cent., of which 2 per cent. represents the allowance for experiments. Control-rod dynamics and reactor runaway behaviour are also discussed. It is shown that the S-5 design has a high inherent safety against runaway, which arises principally from the negative temperature coefficient of reactivity. (North American Aviation Inc.: J. B. Ehrman and W. J. Houghton.)

Particle Size in Homogeneous Graphite Reactor

Heat transfer from the fuel to the moderator during a sudden power increase in a uranium-impregnated graphite-moderated reactor was investigated to determine if the use of relatively large fuel particles inhibits effective operation of the negative temperature coefficient of reactivity. Time lags in heat transfer to the moderator after the sudden introduction of 2 per cent. excess reactivity are given for a lower-power research reactor. The fraction of fission fragments escaping into the moderator is also given in a report of the investigation. It is concluded that radiation damage can be prevented without inhibiting the action of the temperature coefficient. (North American Aviation, Inc.: D. L. Hetrick.)

General Notes

Reactor Physics

The first of a series of articles on the fundamentals of reactor physics, prepared by Mr. G. W. K. Ford, Research Manager of the experimental criticality group at the United Kingdom Atomic Energy Authority's establishment at Dounreay, appears on page 723.

Conference on Nuclear Fuel Cycles

The Institute of Physics has arranged a three-day conference on nuclear fuel cycles to be held at the Institution of Civil Engineers, London, on January 15, 16 and 17, 1958.

Coolant Pumps for Danish Reactor

An order has been received from Head Wrightson Processes Limited for the three 70 horse-power main coolant pumps for the Danish reactor D.R.3 at Risø. These pumps will be of the Hayward Tyler special glandless type, in stainless steel, circulating heavy water in the primary loop and are replicas of those supplied for DIDO and PLUTO at Harwell, MTR, Dounreay and Lucas Heights, Australia. Hayward Tyler and Company, Limited, is a member of the Platt Brothers Group.

British Research Reactor for Germany

Based on the agreement reached between the governments of Great Britain and the Federal Republic of Germany, and in formal conclusion of comprehensive negotiations between the U.K.A.E.A., Land-Nordrhein-Westfalen, and the company Head Wrightson Processes Limited, in connection with the design and engineering of a materials testing reactor, the Land and Head Wrightson Processes have recently signed a contract for co-operation.

The reactor is a high-flux testing reactor similar to DIDO. This order is the sixth reactor awarded to the company and the third for export; Denmark and Australia are the other countries concerned. It is an enriched-uranium heavy-water moderated reactor with a flux of 10^{14} neutrons per sq. cm. per sec. and a thermal output of 10 MW. The new reactor is intended for the Atomic Research Establishment of the Land-Nordrhein-Westfalen. Together with ten research and development laboratories it will be placed at the disposal of the Universities of Aachen, Bonn, Cologne and Münster. The U.K.A.E.A. will supply the enriched fuel elements.

Swedish Medium-Temperature Reactor

The Asea company's atomic energy division

Continuing Atomic Review

is at present said to be investigating the possibilities of developing a medium-temperature reactor on the basis of experience gained in designing the Adam low-temperature reactor. It is claimed that additional heat obtained through the burning of oil should make the plant suitable for both thermal and power-producing purposes. Asea is also interested in building a minor thermal plant using enriched uranium and with a capacity of 35 to 40 MW.

Pool Reactor for Greece

The United States Atomic Energy Commission has issued a licence to American Machine and Foundry Company of New York for export of a research reactor to Greece. The company is shipping a 1,000 kW (heat) pool-type reactor to the Greek Atomic Energy Commission for installation at the Democritus Nuclear Centre in Athens.

Soviet Aircraft Reactor

It is reported that an aircraft carrying a nuclear power plant has completed its first flight tests in the Soviet Union. There is no reason to believe that the aircraft was actually propelled by nuclear means. The report suggests that a nuclear propelled aircraft might fly continuously on a course encircling the earth and employ smaller aircraft for charging and discharging passengers.

Designing Pressure Vessels

A paper entitled "Problems in the Design of Pressure Vessels for the Calder Hall Type of Nuclear Reactor," by Mr. R. W. Lakin, of the A.E.I.—John Thompson Nuclear Energy Company, was presented at a meeting of the North Western Branch of the Institution of Chemical Engineers on November 19. A complementary paper on "Supporting Skirts for Reactor Pressure Vessels," by Dr. R. Hicks, of the G.E.C.—Simon-Carves Atomic Energy Group, was noted in Atomic Review last August 30.

Minimising Cooling-Water Demand

There are so many limitations on the siting of nuclear power stations, that the removal of one is to be welcomed. A proposal discussed on page 733 of this issue concerns the use of cooling towers in which large quantities of water are not required.

Economic Comparison for Merchant Ships

In the paper "The Nuclear Propulsion of Ships," by Sir Christopher Hinton and Mr. R. V. Moore, discussed in Atomic Review last week, there was an interesting graphical comparison of nuclear and conventionally propelled merchant ships. The graph is reproduced in Fig. 3.

First U.S. Full-Scale Power Reactor

The United States Shippingport pressurised-water reactor went critical on December 2. The power will be gradually increased to 60 MW.

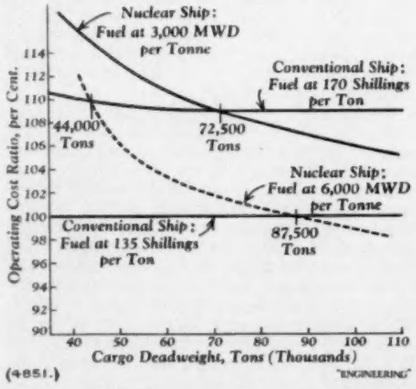
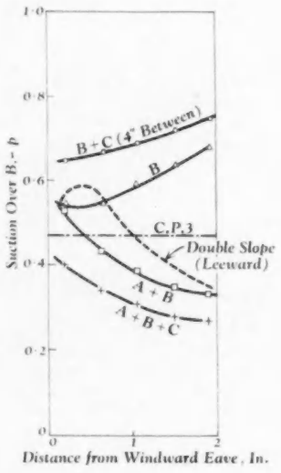

Nuclear Ship: Fuel at 3,000 MWD per Tonne
Conventional Ship: Fuel at 170 Shillings per Ton
44,000 Tons
72,500 Tons
Nuclear Ship: Fuel at 6,000 MWD per Tonne
Conventional Ship: Fuel at 135 Shillings per Ton
87,500 Tons
Operating Cost Ratio, per Cent.
Cargo Deadweight, Tons (Thousands)
(4851.) "ENGINEERING"

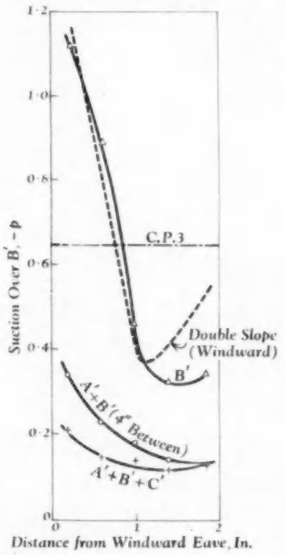
Fig. 3 Economic comparison of 17·5 knot vessels, showing curves for nuclear and conventionally propelled ships. (Hinton and Moore).

Construction

SUCTION ON SINGLE SLOPE ROOFS

By J. D. Haddon,
M.B.E., B.SC., F.R.AE.S.





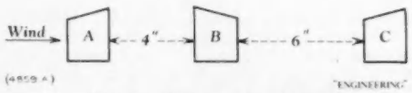


Fig. 1 High eave to windward.

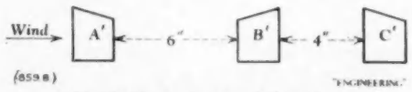


Fig. 2 Low eave to windward.

Figs. 1 and 2 The effects of wind loading on a single-slope roof, with and without adjacent obstructions. For the roof to be safe in an 80 m.p.h. wind, the fixing should be able to withstand an upward force of 25 lb. per sq. ft. of roof less the deadweight of the roof.

THE recent loss of, and damage to, roofs at Hatfield last month has given rise to a great deal of discussion. Many people may be thinking that this was the result of either inadequate Codes of Practice or the unsuitability of aluminium alloy as a roofing material. The author is the last person to agree that Codes are adequate as regards wind suction, but in this case a reasonable interpretation of the relevant code, C.P.3, would have given a suction somewhat similar to that at which the trouble occurred: about 7 lb. per sq. ft. This figure assumes the roofs were sucked off in a 95 m.p.h. wind blowing approximately normal to the row of houses.

The only charge that can be levelled against aluminium alloy is that of lightness. Roofs made of it must be securely held down, as is the case with other lightweight roofs. A roof, 40 ft. by 40 ft. and weighing 5 lb. per sq. ft., on a rectangular shed may, in a 95 m.p.h. gale, have to withstand a net vertical lift of about 20 tons, whatever its slope.

An investigation on wind suction, carried out at the Royal Military College of Science, has been extended to include single-slope roofs with and without local interference. The interference was similar to that at Hatfield and, though the models tested had a slightly greater slope, the same conclusions may be held to apply. The reader is referred to an earlier report[1] for details of the apparatus. Unless otherwise stated the results given here refer to a model 7½ in. long by 2 in. wide and with an eave height of 2 in. at the front and 2½ in. at the back. For ease of experiment and use, all results are given non-dimensionally in terms of

$$p = \frac{\text{actual dynamic pressure, lb. per sq. ft.}}{0{\cdot}0026\ V^2}$$

where V is the wind speed in m.p.h.

The results of the experiments are given in the accompanying graphs. Fig. 1 shows the distribution of suction, at half span, on the model with the higher eave to windward. The dotted line gives the suction over the leeward half of the usual double-slope roof and the chain dotted line that laid down by C.P.3.

It will be seen that the single building *B* has an average suction of 0·6, which is greater than that given by the Code. With the second building *A* to the windward, and *C* to leeward, as at Hatfield, the average suction is reduced to about 0·32. The difficulty of predicting the effects of interference is seen by comparing the results after adding *C* to the leeward. With buildings *A* and *B* present the suction is reduced, but with *B* alone suction is increased.

From Fig. 2 it is seen that the building *B'*, without interference, has a greater average and much greater peak suction than that with the higher eave to the windward. Interference by *A'* reduces the average to 0·15, that is about half that of *B* when interferred with. *C'* was found to have very little effect.

It will be abundantly clear that interference saved the majority of the roofs on the Hatfield estate, without which the undamaged rows would have been the first to go.

Further experiments have shown that with the air-flow axial, the windward end of the roof was subjected to an average suction of 0·8 for a distance equal to the width, leeward of which it rapidly fell to less than 0·1. However, the average suction of 0·8 was felt over the whole length with the air-flow aligned diagonally at about 45 deg.

The greatest suction recorded was 1·91 on a model 4½ in. long with the higher eave to windward and the air flowing diagonally across the model at 50 deg. to the transverse direction. It occurred at a point 0·2 in. from the windward eave and 1 in. from the windward gable.

CONCLUSION

This note may be concluded by recommending

that all roofs, and their attachments, be designed to withstand an upward force of

$$0{\cdot}8 \times 0{\cdot}0026\ V^2 \text{ lb. per sq. ft.}$$

due to external suction, plus an internal pressure of up to

$$0{\cdot}75 \times 0{\cdot}0026\ V^2 \text{ lb. per sq. ft.}$$

depending upon the openings in the buildings, unless further knowledge is available.

Reference

[1] J. D. Haddon, "Wind Loading on Roofs," ENGINEERING, page 559, vol. 184 (November 1, 1957).

MAKING MORE SITES FOR POWER STATIONS

Use of Air-Cooling Towers

The Central Electricity Authority have begun an examination of the possible use of air-cooled heat exchangers and jet condensers in place of water-cooled towers at their power stations. Such equipment would reduce the dependence on large volumes of make-up water, thus materially easing the problem of finding new sites.

The system employs jet condensers instead of surface condensers within the station, and the warmed coolant is pumped in a closed circuit through large heat exchangers—or radiators—fitted around the base of the cooling tower. These exchangers transfer the waste heat directly to the air passing up the tower, whereas in conventional water cooling towers most of the heat is lost by evaporation. Necessarily, the "dry" towers require the circulation of large quantities of air and it is customary to install fans in such systems, which are used extensively in the United States; the equipment would be similar, though of a larger size, to that now used for cooling large Diesel-generator sets. Such air-cooled heat exchangers have also been put in at petroleum and chemical plants, both at home and abroad. In Germany the idea has been taken a stage further than that mentioned in the C.E.A. proposals; there the jet condensers have also been eliminated and the steam from the turbine is passed directly into the air-cooled heat exchanger. However, such an arrangement requires a very large manifold pipe which is difficult to seal against air leaks—with many consequent complications.

In making their announcement the C.E.A. point out that the air-cooled system is likely to be more expensive than water-cooling towers, but observe that other economies might be effected, particularly the saving in fuel transport costs if coal-fired stations could thereby be sited closer to the collieries. Looking further ahead, to the more extensive construction of atomic power stations, which at present require immense quantities of cooling water because of a low steam quality, such an air-cooling system would greatly extend the choice of sites, now restricted to coastal and estuary regions.

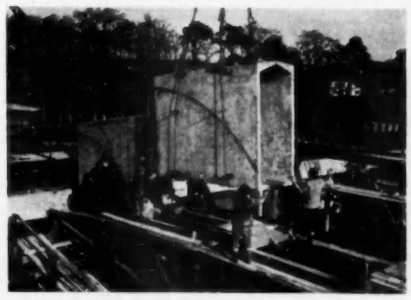
PRE-CAST PRESTRESSED FACTORY CONSTRUCTION

Clear Spans of 105 ft.

Two production halls of identical construction, designed specifically for making cigarettes, are being erected at Ballymena, Northern Ireland. The halls are sited parallel to each other and have annexes on three sides; they are linked at one end by a canteen and administration block. All the buildings are of reinforced concrete and, for economy, speed and finish, are being built of pre-cast units made on the site.

The basic requirements of the production halls are that there shall be very close control of air temperature, humidity and cleanliness, and a column-clear interior to allow for machinery and production improvements. To meet these requirements single-storey concrete construction with north-light shell roofs was chosen. One of the halls is 600 ft. long, the other 900 ft.; both are 105 ft. wide. There are no interior columns, as may be seen from one of the illustrations. Hollow pre-cast main beams (which also serve as the air-conditioning ducts and contain other services) span the full width. The beams have a curved outline, with a soffit radius of just over 300 ft., and are simply supported at 30 ft. centres on hollow columns (2 ft. wide by 14 ft. 10 in. high) built *in situ* in the external walls. On one side, the columns contain a rocker bearing to permit expansion. Services are fed to the main beam through the hollow columns from a reinforced-concrete tunnel running the full length of each hall.

Each main beam is 9 ft. deep by 4 ft. wide and is made up of seven pre-cast hollow-box units, each 12 ft. 8 in. long, and six intermediate diaphragms, each 2 ft. thick. To form the beams, the units are prestressed together by 14 cables (each of 12 wires) using the Gifford-Udall-CCL system. The box units have 4 in. walls and were pre-cast as two separate channels, each 2 ft. deep, which were afterwards mortared together by a simple butt joint; additional bolting together was also used during erection and until the prestress had been applied. The diaphragms have walls 9 in. thick and were cast in one piece.



Box sections of the main beams being erected.

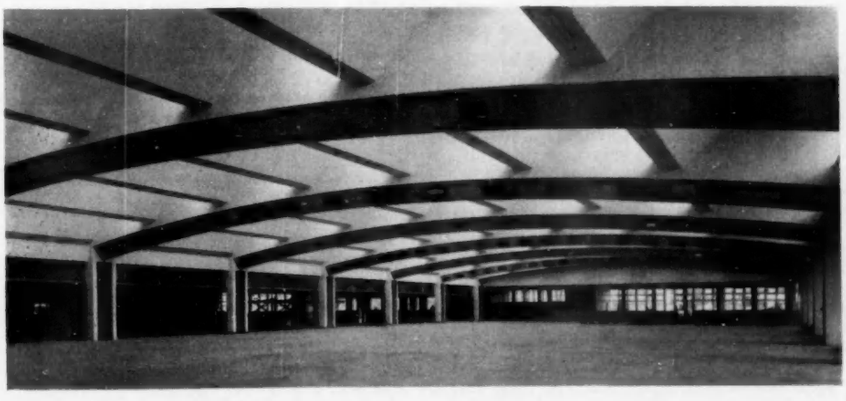
Seven pre-cast north-light shell units, side by side, span between each pair of main beams, each shell being 15 ft. wide by 26 ft.; they are 3 in. thick and each weighs 9 tons. The valley beams were pre-cast separately.

All the pre-cast units have been erected using a 15 ton derrick. A complete bay of a production hall has been erected and finished on average every nine days. The beam units were slung into their final position and supported on a timber gantry until they were mortared together and prestressed. The cables are contained inside the beam, seven against each side wall; in the hollow-box units, the cables were exposed initially but in the diaphragms they had to be threaded through ducts in the side walls. Strengthened diaphragm units have been used for the end blocks which contain the anchorages. After stressing, the cables were concreted solid with the wall of the box unit to ensure complete cover; grouting has been used where the cables pass through the diaphragm.

Expansion joints are provided at 210 ft. centres in the lengths of the halls. Each joint was formed by splitting the main beams in half longitudinally and the hollow columns in half vertically. To ensure that the beams would be completely stable until after the shell roof units were in position each beam was erected in the normal way but with a wooden filler in place of the mortar joints; a similar filler was also inserted when casting the diaphragm units. After erecting the shells on both sides of the beam, the artificial joints were knocked out and the reinforcement between the two sections of the diaphragm cut.

All the structural members were cast in a central yard which covers an area of 100 ft. by 300 ft. and served by a 15 ton derrick. Shutterwork was generally of timber with high-grade plywood liners for exposed soffits. It was found possible to get about 30 uses of the forms before reconditioning was required. A 1 : 4½ concrete mix was used and shuttering was stripped at three days. Average compressive strengths of 8,000 lb. per sq. in. at 28 days have been obtained from the test cubes.

The factory is being built for Gallaher Limited by Sir Alfred McAlpine and Son, Wirral, Cheshire. The consulting engineers are Sir Alexander Gibb and Partners, Westminster.



The clear floor width of this single-storey factory is 105 ft.

Pre-cast shells being lowered into position, strengthened by "strong-backs."

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
"Electricity in the Gas Industry," by H. F. Buxton. South West London Branch. Prince of Wales Hotel, Wimbledon, S.W.19. Thurs., Dec. 12, 7.45 p.m.

British Institution of Radio Engineers

EDINBURGH
"High-Quality Sound Reproduction," by R. E. Cooke. Scottish Section. Department of Natural Philosophy, The University, Edinburgh. Fri., Dec. 13, 7 p.m.

GLASGOW
"High-Quality Sound Reproduction," by R. E. Cooke. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Dec. 12, 7 p.m.

MANCHESTER
"Process Heating," by M. O'C. Horgan. North Western Section. College of Technology, Sackville-street, Manchester 1. Thurs., Dec. 12, 6.30 p.m.

NEWCASTLE-UPON-TYNE
"Stereophonic Sound and Tape Recorders," by D. H. McBean. North Eastern Section. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Wed., Dec. 11, 6 p.m.

Building Centre

LONDON
Films: "The Yorkshire Way with Water," exhibited by the Yorkshire Copper Works Ltd. Wed., Dec. 11, 12.45 p.m.

Chemical Society

LONDON
Various short papers. Thurs., Dec. 12, 7.30 p.m.

Combustion Engineering Association

LEEDS
"The Burning of Difficult Fuels," by E. J. MacDonald, at 10.30 a.m. "Methods of Smoke Measurement and Control," by G. Nonhebel, at 2.30 p.m. Northern Region. Hotel Metropole, Leeds. Wed., Dec. 11.

Engineering Metrology Association

LONDON
"Thread Grinding," by H. B. Perry. Thurs., Dec. 12, 7 p.m.

Illuminating Engineering Society

LONDON
"Television Studio Lighting Equipment," by K. R. Ackerman. Federation of British Industries, 21 Tothill-street, S.W.1. Tues., Dec. 10, 6 p.m.

HULL
"Commercial and Industrial Lighting," by J. C. Harcourt. Leeds Centre. Offices of the Yorkshire Electricity Board, Ferensway, Hull. Tues., Dec. 10, 6.30 p.m.*

LEEDS
"Turning Night into Day: Some Interesting Wartime Secrets," by C. H. Wood. Leeds Centre. Lighting Service Bureau, 24 Aire-street, Leeds, 1. Mon., Dec. 9, 6.15 p.m.*

Incorporated Plant Engineers

BIRMINGHAM
"Torque Convertors," by A. L. Gattis. Birmingham Branch. Imperial Hotel, Temple-street, Birmingham. Fri., Dec. 13, 7.30 p.m.

BRISTOL
"Air Compressors," by A. H. Bailey. Western Branch. Grand Hotel, Bristol. Wed., Dec. 11, 7.15 p.m.

GLASGOW
"Electric Arc Welding," by Dr. J. W. Macfarlane. Glasgow Branch. Scottish Building Centre, 425/427 Sauchiehall-street, Glasgow. Thurs., Dec. 12, 7.15 p.m.

LIVERPOOL
Discussion on "Heating and Ventilating." Merseyside and North Wales Branch. Exchange Hotel, Liverpool. Thurs., Dec. 12, 7.15 p.m.

Institute of Fuel

MANCHESTER
"Gas Producers," by Sinclair Gaskill. North Western Section. Engineers' Club, Albert-square, Manchester. Wed., Dec. 11, 2.30 p.m.

SHEFFIELD
"Treatment of Boiler Feedwater and Cooling Waters," by G. T. Peat. Yorkshire Section. Royal Victoria Hotel, Sheffield. Wed., Dec. 11, 2.30 p.m.

Institute of Marine Engineers

GLASGOW
"Higher Speed Internal Combustion Machinery for Marine Propulsion," by J. Calderwood. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Wed., Dec. 11, 7.30 p.m.

Institute of Marine Engineers and Institution of Naval Architects

PORTSMOUTH
"Use of High Pressure Steam for Marine Installations," by E. Norton. Southern Joint Branch. Portsmouth College of Technology, Portsmouth. Mon., Dec. 9, 7.30 p.m.

Institute of Metals

LONDON
"Properties of Castings," by F. Hudson. London Local Section. Constitutional Club, Northumberland-avenue, W.C.2. Wed., Dec. 11, 7.30 p.m.

GLASGOW
"Recent Developments in Magnesium-Base Alloys," by Dr. E. F. Emley. Scottish Local Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Mon., Dec. 9, 6.30 p.m.

SWANSEA
"Hardness of Metals," by Dr. D. Tabor. South Wales Local Section. Department of Metallurgy, University College, Singleton Park, Swansea. Tues., Dec. 10, 6.30 p.m.*

Institute of Packaging

LEEDS
Films: "Hazards in Transport." Leeds and Bradford Branch. Great Northern Hotel, Leeds 1. Thurs., Dec. 12, 7.30 p.m.

Institute of Physics

LONDON
"Infra-Red and Microwave Modulators Using Free Carriers in Germanium," by Dr. A. F. Gibson. Electronics Group. Tues., Dec. 10, 5.30 p.m.*
"Irregularities and Movements in the Ionosphere," by Dr. B. H. Briggs. London and Home Counties Branch. Wed., Dec. 11, 6 p.m.*

GLASGOW
"Lord Kelvin," by Professor P. I. Dee. Scottish Branch. Royal Philosophical Society of Glasgow, 207 Bath-street, Glasgow. Wed., Dec. 11, 7 p.m.

MANCHESTER
"The Strength of Materials, with Special Reference to Metals," by Dr. A. H. Cottrell. Manchester Branch. Bragg Lecture Theatre, The University, Manchester. Fri., Dec. 13, 6.45 p.m.

Institute of Road Transport Engineers

BIRMINGHAM
"Exhaust Brake Design and Operation," by A. G. Slee. Midlands Centre. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham. Tues., Dec. 10, 7.30 p.m.

CARDIFF
"The N-type Injector Pumps and the Hydraulic Governor," by T. G. Charlesworth. South Wales Centre. South Wales Institute of Engineers, Park-place, Cardiff. Fri., Dec. 13, 7 p.m.

MANCHESTER
Discussion on "Tyres and Their Maintenance." East Regional Centre. 90 Deansgate, Manchester. Mon., Dec. 9, 7.30 p.m.

Institution of Chemical Engineers

BIRMINGHAM
"Models for Piping Design and Construction," by M. K. Brown and E. Holmes. Midlands Branch. Midland Institute, Paradise-street, Birmingham. Wed., Dec. 11, 6.30 p.m.

Institution of Civil Engineers

LONDON
Symposium on "Airfield Construction on Overseas Soils," by K. E. Clare, M. J. Tomlinson, I. K. Nixon and B. O. Skipp. Tues., Dec. 10, 5.30 p.m.*

PRESTON
"Modern Road Construction," by A. G. Tarrant. North Western Association. County Hall, Preston. Wed., Dec. 11, 6.15 p.m.

Institution of Electrical Engineers

LONDON
Discussion on "Where Should Research End and Development Start?" opened by Dr. K. J. R. Wilkinson. Mon., Dec. 9, 5.30 p.m.*
"A Flying-Spot Film Scanner for Colour Television," by H. E. Holman, G. C. Newton and S. F. Quinn. Radio and Telecommunication Section. Wed., Dec. 11, 5.30 p.m.*
"Electrical Control of Stage and Television Lighting," by F. Bentham. Utilization and Radio Sections. Thurs., Dec. 12, 5.30 p.m.*
Discussion on "Basic Experiments on Servo Mechanisms," opened by W. Chellingsworth. Education Discussion Circle. Fri., Dec. 13, 6 p.m.*

BELFAST
"Factors in the Utilisation of Electrical Power in Aircraft," by H. Zeffert. Northern Ireland Centre. David Keir Building, Queen's University, Belfast. Tues., Dec. 10, 6.30 p.m.

CARDIFF
"138 kV Submarine Power Cable Interconnection Between the Mainland of British Columbia and Vancouver Island," by Dr. T. Ingledow and others. Western Centre. South Wales Institute of Engineers, Park-place, Cardiff. Mon., Dec. 9, 6 p.m.*

LEICESTER
"Highland Water Power," by the late Mr. T. Lawrie. East Midland Centre. Leicester College of Technology, Leicester. Fri., Dec. 13, 7.15 p.m.

LIVERPOOL
"Electrical Equipment for Rectifier Locomotives," by H. B. Calverley, E. A. K. Jarvis and E. Williams. Mersey and North Wales Centre. Royal Institute, Colquitt-street, Liverpool. Mon., Dec. 9, 6.30 p.m.

Institution of Engineering Designers

NEWCASTLE-UPON-TYNE
"Doxford Marine Diesel Engines," by J. A. Hardy. 6 Higham-place, Newcastle-upon-Tyne. Mon., Dec. 9, 7.15 p.m.

Institution of Heating and Ventilating Engineers

MANCHESTER
"Mechanical Services in the B.E.A. Maintenance Hangars, London Airport," by L. Copeland Watts. Manchester Branch. Engineers' Club, Albert-square, Manchester. Fri., Dec. 13, 6.30 p.m.

Institution of Mechanical Engineers

LONDON
Discussion on "Air or Water Cooling?" Automobile Division. Tues., Dec. 10, 6.45 p.m.*
Discussion on "Reclamation of Lubricants." Lubrication Group. Wed., Dec. 11, 6.45 p.m.*
James Clayton Lecture on "High-Pressure Hydraulic Transmission," by Dr. Hans Thoma. Fri., Dec. 13, 6 p.m.*

DERBY
"Small Gas Turbines," by Dr. J. H. Weaving. East Midlands Branch and Derby A.D. Centre. Rolls-Royce Welfare Hall, Derby. Mon., Dec. 9, 6.15 p.m.

LEEDS
"Atomic Energy, Steam and Power Production," by W. R. Wootton. Yorkshire Branch. Hotel Metropole, Leeds. Thurs., Dec. 12, 6.30 p.m.

Institution of Production Engineers

LONDON
"Pneumatic Gauging in Metrology," by Dr. J. C. Evans. London Graduate Section. Tues., Dec. 10, 7.15 p.m.

CHATHAM
"Practical Uses of Electronics in Industry," by K. A. Zandstra. Rochester Section. Sun Hotel, Chatham. Thurs., Dec. 12, 7.30 p.m.

LEEDS
"High Cost of Low Overheads," by C. H. Starr. Leeds Section. Hotel Metropole, King-street, Leeds. Mon., Dec. 9, 7 p.m.

SWANSEA
"Punched Card Development in Automation," by D. Nettel. Swansea Section. Central Library, Alexandra-road, Swansea. Fri., Dec. 13, 7.30 p.m.

Institution of the Rubber Industry

LONDON
"Butyl in Mechanical Rubber Goods," by Dr. M. E. Blowin. London Section. 26 Portland-place, W.1. Tues., Dec. 10 5.30 p.m.

Institution of Structural Engineers

LONDON
Maclachlan lecture on "Tandem Ferry Aprons for the Canadian Pacific Railway at Vancouver and Nanaimo, B.C., Canada," by P. L. Easterbrook. Thurs., Dec. 12, 6 p.m.*

Junior Institution of Engineers

LONDON
Presidential Address on "Origin and Function of R.E.M.E." by Major-General W. A. Lord. Fri., Dec. 13, 7.30 p.m.*

Manchester Association of Engineers

MANCHESTER
"Chemical Engineering Education," by Professor F. Morton. Engineers' Club, Albert-square, Manchester. Fri., Dec. 13, 6.45 p.m.

Newcomen Society

LONDON
"Abraham Darby (I and II) and the Coal-Iron Industry," by Dr. R. A. Mott. Wed., Dec. 11, 5.30 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE-UPON-TYNE
"Analysis of Structures—Prediction of Deflections," by T. M. Charlton. Mining Institute, Newcastle-upon-Tyne. Fri., Dec. 13, 6.15 p.m.*

Physical Society

LONDON
"Paris Meeting on Colour Television," by L. C. Jesty, and other papers. Colour Group. Imperial College, South Kensington, S.W.7. Wed., Dec. 11, 3.30 p.m.

Reinforced Concrete Association

LONDON
"Some Reinforced Concrete Works in Europe and Asia," by N. A. Sadleir. 11 Upper Belgrave-street, S.W.1. Wed., Dec. 11, 6 p.m.*

Royal Aeronautical Society

LONDON
"Ram Jets," by R. P. Probert. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Thurs., Dec. 12, 6 p.m.*

Royal Institution

LONDON
"A Debt to Defects," by Professor Ronald King. Fri., Dec. 13, 9 p.m.

Sheffield Metallurgical Association

SHEFFIELD
"Some Everyday Refractory Problems," by Dr. P. W. Clark. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield. Tues., Dec. 10, 7 p.m.

Society of Instrument Technology

LONDON
"Automatic Profiling Systems for Machine Tools," by R. Lawson. 26 Portland-place, W.1. Wed., Dec. 11, 7 p.m.*

South Wales Institute of Engineers

CARDIFF
"Development of Hydrox for Underground Loading," by Dr. I. O. Lewis and R. Watt. Thurs., Dec. 12, 6 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Combustion Engineering Association, 6 Duke-street, St. James's London, S.W.1. (WHItehall 5536.)
Engineering Metrology Association, Northampton Polytechnic, St. John-street, London, E.C.1. (CLErkenwell 1662.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, Memorial Building, 76 Mark-lane, London, E.C.3. (ROYal 8493.)
Institute of Metals, 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institute of Packaging. Apply to Mr. H. Williams, 80 Lancaster-avenue, London, S.E.27. (GIPsy Hill 4859.)
Institute of Physics, 47 Belgrave-square, London, S.W.1. (BELgravia 6111.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 4 Kensington Palace-gardens, London, W.8. (BAYswater 9101.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Manchester Association of Engineers, 18 Booth-street, Manchester 2. (Central 1717.)
Newcomen Society, Science Museum, Exhibition-road, London, S.W.7. (KENsington 1793.)
North East Coast Institution of Engineers and Shipbuilders Bolbec Hall, Newcastle-upon-Tyne 1. (Newcastle 20289.)
Physical Society, 1 Lowther-gardens, South Kensington, London, S.W.7. (KENsington 0048.)
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Institution, 21 Albemarle-street, London, W.1. (HYDe Park 0669.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield 10. (Sheffield 62144.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)
South Wales Institute of Engineers, Park-place, Cardiff. (Cardiff 23296.)

In Parliament

ENGINEERS WHO EMIGRATE

A number of matters within the purview of the Department of Scientific and Industrial Research came before the House of Commons last week. One of them concerned the emigration of British engineers and scientists overseas, especially to Canada and the United States.

On this subject, Mr. Frederick Willey (Labour) asked the Parliamentary Secretary to the Ministry of Works to state what action was being taken regarding the suggestion that had been made in the annual report of the Advisory Council on Scientific Policy, for 1956-57. Replying in his capacity as the representative in the Commons for the Lord President of the Council, Mr. Harmar Nicholls said that the suggestion that firms in this country might make arrangements to interview British engineers and scientists in North America had been referred to the appropriate committees of the Federation of British Industries for investigation. The D.S.I.R. was considering what action could be taken to encourage more engineers and scientists from this country to undertake their post-graduate work in Europe.

Another subject referred to was the extent to which progress was being made in the United Kingdom in the use of solar heat for research experiments not possible or convenient with other heat sources. In this connection, Mr. Nicholls told Sir William Wakefield (Conservative) that solar radiation was not at present being used in this country to produce high temperatures for research purposes. In the United Kingdom, solar energy could never be used as regularly as in those parts of the world which were more favoured geographically.

RUSSIAN SCIENCE IN ENGLISH

Mr. Austen Albu (Labour) wanted to know what arrangements were being made to increase the availability of translations of Russian scientific papers and books.

He was informed by Mr. Nicholls that the D.S.I.R. had started a comprehensive collection of English language translations of Russian scientific and technological literature in all fields, except clinical medicine. The material collected was being made available through the Department's lending library unit, which also lends technical literature in Russian to research organisations, industrial establishments, universities, colleges, and Government departments. In addition, microfilms of several thousand translations of Russian scientific papers had been ordered from a library in Chicago, which houses the main collection of Russian technical material in the United States.

In conjunction with the Scientific Library and Technical Information Committee of the Advisory Council on Scientific Policy, the D.S.I.R. was reviewing the question of what additional measures were necessary to improve the quantity of translations of Russian scientific papers and books, which was being undertaken in the English-speaking world.

WHITE LINES AS TRAFFIC GUIDES

The House was informed by Mr. Harold Watkinson, the Minister of Transport and Civil Aviation, that a careful study of new forms of road markings had been made as a result of experiments on the Portsmouth and Folkestone-Dover roads. He had now come to the conclusion that the best system for use in this country would be to employ three types of longitudinal markings: short dotted lines with long gaps between the dots, to indicate traffic lanes; longer broken lines with short gaps between the lines, to warn traffic of a hazard ahead; and double lines where a prohibition on crossing from one side or the other was necessary. The present single continuous line would eventually disappear altogether. It was his intention, he told Mr. Leslie Thomas (Conservative), to introduce a strict prohibition on the crossing or straddling of the continuous line, where the double marking was used, but it would not be practicable to take such action until the new system had become familiar throughout the country. The new system would be consistent with the practice in vogue in other European countries.

SHIPOWNERS' RESPONSIBILITIES

The subjects discussed at the tenth session of the Diplomatic Conference on Maritime Law in Brussels, which ended on October 10 last, were three draft conventions on the limitation of shipowners' liability for damages, on liability in respect of passengers, and on stowaways. The use of life-saving apparatus was not discussed.

Mr. Watkinson informed the House that the United Kingdom delegation supported the principles contained in the Convention on the Limitation of Shipowners' Liability and voted for the acceptance of the convention by the conference. This convention, he told Mr. Hector Hughes (Labour), deals with liability both in respect of the loss of life and personal injury, and in respect of the loss of property and damage thereto.

The United Kingdom delegation was unable to support the convention for dealing with problems relating to stowaways. The draft convention relating to shipowners' liabilities in respect of passengers was revised by the conference and will be circulated to the Governments concerned for further study.

ELECTRICAL CONTRACTING APPRENTICESHIPS

The Minister of Works was asked by Mr. Arthur Lewis (Labour) to prevail upon the employers in the electrical contracting industry to accept the proposals put forward by the chairman of the Apprenticeship and Training Council for the Electrical Contracting Industry.

In reply, Mr. Hugh Molson said that, at his invitation, the President of the employers' association for the industry had been to see him. He had asked the President to persuade his organisation and its members to accept the proposals of the chairman of the Apprenticeship and Training Council, Sir George Gater, G.C.M.G., and to find the necessary finance. The President had explained to him, Mr. Molson stated, that his members did not consider registration in the industry to be either necessary or useful. He had been glad to learn, however, that there would be no alteration in the support given by the employers to the training arrangements in the industry and, in particular, to indentured apprenticeships.

Mr. Molson was continuing to provide secretarial services to the Apprenticeship and Training Council, until arrangements had been completed for the future administration of the Council's further education fund. At the same time, he had not been prepared to continue the registration work beyond November 30, that being the date fixed for its termination.

VOLTA RIVER ALUMINIUM PROJECT

A number of members pressed the Government to reconsider their decision of July 27, 1956, in which they declined to commit themselves to participating in the financing of the Volta River project, until a general assessment had been made by the International Bank, and until an agreement on the framework of the project had been reached between the Governments of the United Kingdom and Ghana and the aluminium companies concerned.

As pointed out at that date by Mr. Alan Lennox-Boyd, the Secretary of State for the Colonies, the project covered the construction of a dam, smelter, mines and ancillary services and, based on two stages of aluminium production, would cost £184·9 million (with a capacity of 120,000 tons a year) rising to a total of £231·3 million (with a capacity of 210,000 tons per annum).

In his reply to the representations made to him in the House last week, Mr. Cuthbert Alport, the Under-Secretary of State for Commonwealth Relations, said that, as had been explained in 1956, the report of the Preparatory Commission on the Volta River Project showed that there were certain conditions which would be prerequisite to any decision about the implementation of the scheme. Some of the major decisions which were required could be taken only by the aluminium companies, whose contributions of capital would be large. The Government of Ghana were in touch with the United Kingdom Government and the aluminium companies and, in these circumstances, the United Kingdom Government must await the outcome of the discussions between Ghana and the aluminium firms.

Mr. Alport told Mr. Edward Mallalieu (Labour) that the Government had made quite clear their continuing interest in the scheme, but it was a highly technical project, and one which depended upon commercial considerations.

Research at Royal Ordnance Factories

Information was desired by Mr. Christopher Mayhew (Labour) regarding the proportion of all naval research, development and production work which had been undertaken by the Royal Ordnance Factories in the years 1954, 1955 and 1956. In reply, Mr. T. G. D. Galbraith, Civil Lord of the Admiralty, pointed out that these factories were essentially large production establishments and that, for that reason, they had not been used to any extent for naval research and development. The figures of naval research, development and production undertaken there during the three years referred to were not readily available, but the proportion would have been about 5 per cent. of the total programme. It had to be borne in mind that only a very small proportion of the whole programme was of a kind which the factories could undertake.

Admiralty Civilian Employees

Replying to Commander John Maitland (Conservative), who asked for a forecast of the extent to which the numbers of industrial and non-industrial civilian employees of the Admiralty were likely to be reduced when the present defence economies were completed, Mr. Galbraith stated that about 181,400 civilians, including police and Royal Fleet Auxiliary personnel, were in Admiralty employment on April 1, last. Considerable reductions would certainly be made during the next few years but it was too early to forecast what the figure would be when the Navy was placed on an all-regular basis in 1962.

Providing New Technical Colleges

Asked by Mr. Eric Fletcher (Labour) about the progress that had been made with the building of new technical colleges since the publication of the White Paper on *Technical Education* (H.M.S.O., Cmd. 9703, 1*s*. 9*d*.) in February, 1956, Mr. Geoffrey Lloyd, the Minister of Education, said that that work had commenced in connection with 18 new colleges and 79 major extensions to existing colleges. In addition, final plans had been approved for five more new colleges and 17 further major extensions, having a total value of £5 million, although work on them had not actually started. The Government had also prepared sketch plans for an additional 14 new colleges and 28 major extensions, to the value of more than £8 million.

Part-Time Technical Students

Later, Mr. Geoffrey Lloyd told Mr. Fletcher that no fewer than 31,700 part-time day students were engaged in taking higher technical education courses during the 1955-56 session. Figures for evening students were not available. Nevertheless, the Government sincerely hoped that these figures would show an increase during succeeding sessions. They considered that there would be an increase, at least in proportion to the Government's general plans over the years, to not less than double the number.

The Human Element

Uneasy Lies the Head

The anti-Communists in the Electrical Trades Union who are attempting to wrestle the control from the Communist executive are having a difficult time. They are up against a group of people who are past masters in the art of twisting the meaning of rules to their own ends as far as they dare go without an open and nation-wide revolt in their membership. The opposition to the executive will have to be equally cunning if it is to succeed. Its recent group of candidates for election to the executive were defeated because the present executive were able to invalidate certain voting papers on what was no more than a technical breach. Nevertheless the technical breach, unless it is further challenged by recourse to law, was unearthed and it is a fatal tactical mistake to go into a battle of this kind without being absolutely sure of one's constitutional and administrative ground.

Last week the union held its rules revision conference. Some of the proposed amendments were exceedingly controversial, especially the one which increases the discretion of the executive in the choice of members to the general-purpose sub-committee which in fact runs the union. At present this sub-committee consists of three officers and the two nearest executive members to London. Under the amendment, the executive could appoint any two members. Since Communists are entrenched in a wide range of branches this move, if successful, will force the anti-Communist element to spread its resources over a wider campaign. The amendments of the executive are thought to have been carried—but an eloquent secrecy enshrouds the outcome as yet.

Blunt Negative

The London Transport Executive has given a blunt negative reply to the bus workers' demand for an increase in pay. This is the first rejection of a pay demand put out by nationalised industry and the precedent it sets, both as regards the decision itself and the negotiating procedure which may follow it, is important for the rest of the winter wage claims which are coming forward.

The claim could go to arbitration although there is no automatic arbitration machinery in the L.T.E. negotiating procedure. No doubt, the officials of the Transport and General Workers' Union would prefer the way of arbitration since they are at present more than a little cool towards a claim. They had hoped to make the London bus operatives' demand part of a wider claim but the London section, with customary independence and militancy, beat the gun. It cannot be ruled out that the local officials of the union will become swayed by a demand for a more militant attitude in the claim than arbitration. There are not likely to be any developments until December 9 when a delegate conference of London bus men will meet to consider the situation. Those who have been conducting the negotiations did not bring even the small crumbs of a counter-offer from the L.T.E. and this fact is not likely to sweeten the discussions when the bus men meet.

Her Proper Place

A recent Government publication expressed confidence that the nation's growing needs for qualified scientists and technicians would be met if "individual talented *boys and girls* chose to take up careers in science and engineering." This official recognition that women have a place and a part to play in the engineering industry was quoted by Miss Helen Bailey of the Economic League in a paper read to the British Institute of Management's national conference at Bournemouth. Under the title "Women at Work," Miss Bailey reviewed the changes that have taken place in the employment of women and the opportunities now open to them. Only 80 years ago a spokesman for the Parliamentary Committee of the Trades Union Congress pointed out that the duty of husbands was to make it possible that their wives should be "in their proper sphere at home, instead of being dragged into competition of livelihood with the great strong men of the world."

There are now nearly 3 million women working in manufacturing industries and over 1½ million in the distributive trades. Half a million work in engineering factories, 173,000 in the metal industries and 170,000 in the motor vehicle industry. The number of careers open to women and the number of women taking up careers has increased considerably since the war. Miss Bailey pointed out that "the increased use of labour-saving devices in the home makes it possible for women to have worthwhile careers while not neglecting their role of housewives and mothers." The application of time controls to cooking stoves, for example, means a housewife can return home at six or seven o'clock to find soup, roast, vegetables and pudding cooked ready to serve. The oven and each ring can be pre-set to start at the appropriate time, maintain the required temperature and switched off when the food is cooked.

Careers in engineering are gaining in popularity. The Women's Engineering Society called a weekend conference last July for girls in the engineering industry. They can now be found holding posts in some 30 branches of the industry, ranging from aero-dynamicists to planning engineers and purchasing officers. As Miss Bailey pointed out, "the fact that such a conference was held is both a sign of the times and the shape of things to come."

All in this Together

The B.I.M. national conference heard a most interesting account of recent research into "Psychological Factors in Group Relations" by Dr. A. T. M. Wilson of the Tavistock Institute of Human Relations. Dr. Wilson has himself, as the chairman of the Institute's management committee, played a big part in instigating and supervising such research.

This is a "young field" of research where, in Dr. Wilson's opinion, there is "still nothing like enough in the way of research programmes—that is, integrated studies by a continuing group." Managers are beginning to realise that there exists immense scope for improvement in productivity, provided the workers concerned are interested in the quantity and quality of their output and are deriving satisfaction from the type of work they do and the conditions in which they work. Traditional incentives, such as piece-rate payments, bonuses based on profitability, and the like have lost much of their initial glitter. We are discovering that social factors play a large part in determining the behaviour, effort and work consciousness of individuals.

The research into "group relations" has already revealed many surprising things, particularly concerning motives and loyalties, but it has mainly established a case for further research. We are just beginning to analyse, by the application of the scientific method to social problems, social factors of the greatest importance in the work situation.

Predisposed to Favour

The arrival last week of the 200th overseas engineer under the Overseas Scholarship Scheme of the Federation of British Industries was the occasion for a celebration. Without doubt the scheme, which began on a modest scale in 1950, has proved a great success. Unfortunately, there has been a most inadequate response from industry, where the presence of foreign students is often regarded as a nuisance.

The F.B.I. have done their job of publicising the overseas scholarship scheme very well and can derive satisfaction that 200 students have arrived here in seven to eight years. But it could and should have been 2,000. The F.B.I. say: "Whilst in Britain they are able to make themselves familiar with British engineering practice, methods and equipment and to see at first hand the British way of life. After completion of training they return home better equipped than before to play a leading part in the development of their own countries." What they don't say, which is equally important, is that they will go back with a will to use or buy British equipment. Germany, the United States, Japan, Soviet Russia, are all only too ready to give training to engineers from the countries they supply. Our effort needs to be even greater.

Passengers—With Care

The report to the Minister of Transport and Civil Aviation on railway accidents in 1956 (H.M. Stationery Office, 3*s*.) shows a welcome absence of fatal train casualties among passengers but a not so welcome increase in the number of accidents last year due to a failure on the part of the human element. Total fatalities in all movements by rail came to 237 (many of these being of a minor nature) compared with 288 in 1955 and 211 in 1954. This last figure was a record. The number of accidents attributable to want of care or irregularities by operating staff went up by nearly 10 per cent. to 640.

It is apparent that the number of accidents caused by human failure is increasing over a number of years. It has, in fact, been rising since 1950 when the figure was 518 and only 45 per cent. of the total accidents in that year. In 1956 the total of 640 amounted to 52 per cent. of total accidents. The chief inspector draws attention to the increase in accidents due to signalmen's errors but considers the figures small in relation to the amount of traffic handled. There has also been an increase in accidents caused by errors of judgment of train crews.

The tendency for human errors of judgment to increase despite the modernisation of railway equipment will have to be watched. The report can give no reason for this increase but it would be in the interests both of the men and British Railways if an objective inquiry could be made.

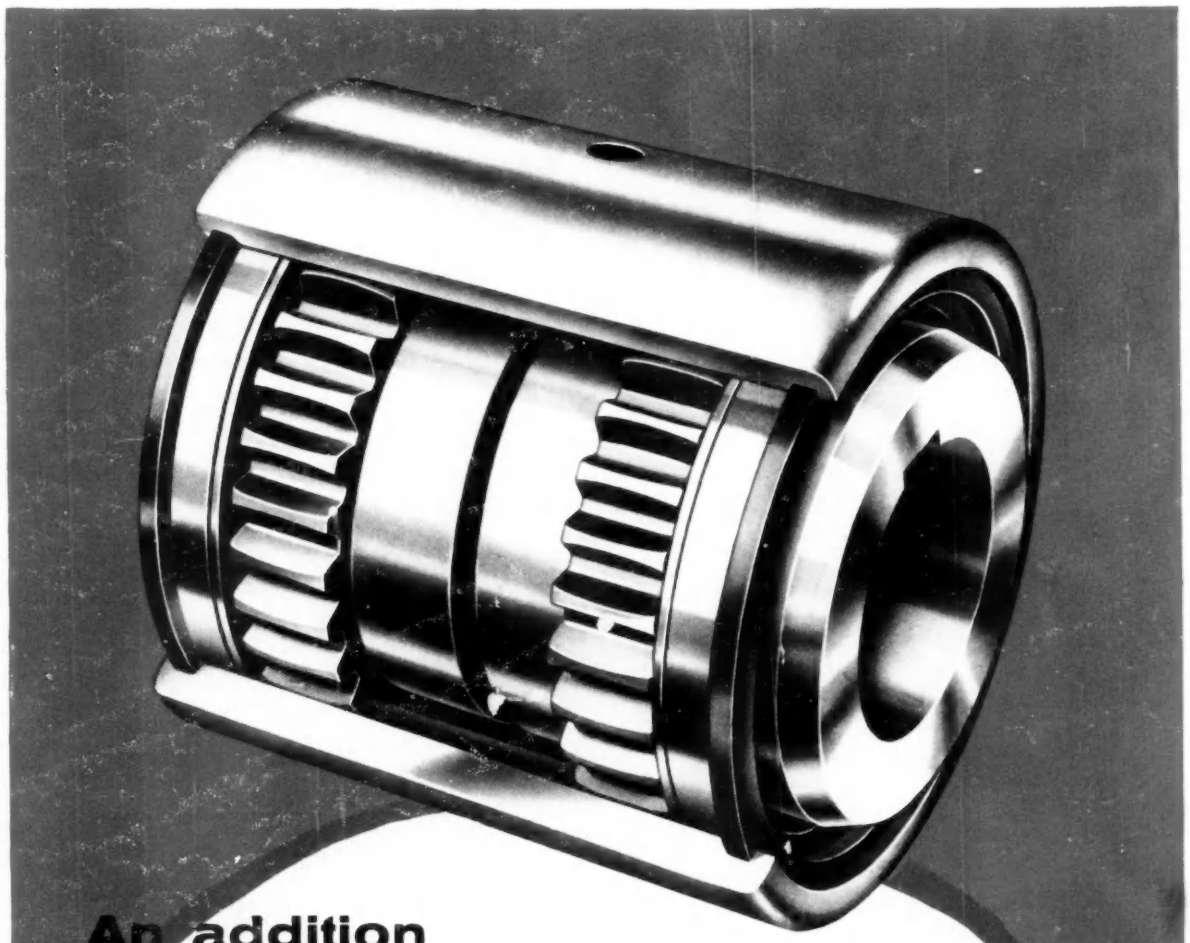
Facts about the Boss

Managers for Tomorrow is the title of the second leaflet in the series "Problems of Progress in Industry," sponsored by the Department of Scientific and Industrial Research. It was prepared by Miss Rosemary Stewart on the basis of a full report, *Management Succession*, published by the Acton Society Trust (10*s*. 6*d*.).

Miss Stewart has produced a very comprehensive little book of rules and a general guide on how to find potential managers and how to train them. Very sensibly, she starts with an analysis of the main characteristics of to-day's manager corps. Only 19 per cent. have a university education, a third of them in arts. Half of them did not have a grammar schooling of any kind: "this means that they were mostly born into working class or lower middle-class families." Yet it seems that boys from public or grammar schools have "more chance of reaching the top than others." A shocking thought is that less than one-third had a professional qualification and that only six-thirteenths of these were qualifications in engineering; four-thirteenths were accountants or secretaries, two-thirteenths chemists and one-thirteenth of varied backgrounds.

ENGINEERING

An Illustrated Weekly Journal



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